

Halley Flyby Mission

mission to Halley should be designed to maximize the use of the objectives of the comet exploration mission set down by the NASA Comet Science Working Group and the Space Science Board (Report of the Comet Science Working Group, NASA TM 80543, 1979; Strategy for Exploration of Primitive Solar System Bodies—Asteroids, Comets, and Meteoroids: 1980-1990, Committee on Asteroids and Meteoroids, Space Science Board, Washington, DC, 1980). In order of priority, these objectives are:

1. Determine the chemical nature and physical structure of the nucleus and to characterize the changes that occur as a function of time and orbital position;
2. Characterize the chemical and physical nature of the nucleus and ionosphere of comets, as well as the processes that occur in them, and to characterize the development of the atmospheres and ionospheres as functions of orbital position;
3. Determine the nature of comet tails and of the processes by which they are formed and to characterize the interaction of comets with the solar wind.

In the context of a Halley mission, these can be summarized as follows:

1. Determine the appearance of the nucleus of Comet Halley (a) size and shape, (b) structure, (c) heterogeneity, (d) chemical composition and physical properties, and (e) volatile material emitted by the nucleus;
2. Characterize the processes that occur in bright, active regions of the nucleus, including (a) chemical and physical processes in the atmosphere and ionosphere, (b) dynamics of dust and ice grains, (c) interaction of the solar wind and the coma, and (d) structure and dynamics of the tails.

EOS

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Views expressed in this publication are those of the authors only and do not reflect official positions of the American Geophysical Union unless expressly stated.

Cover: This image of the terrain of the conterminous United States was composed by an Opticon system from about 550,000 coverage elevation points provided by the U.S. Department of Defense. A contour interval of 121 m was used between 15- and 500-m elevation, and one of 515 m above that elevation. The outline of the conterminous United States is not precise because the contours begin at an altitude of 15 m.

Well-known geologic features like the Mississippi Embayment, the Snake River Plain, the Basin and Range, and various mountain ranges are readily recognizable. Of perhaps greater interest are features and characteristics not previously recognized or reported in the literature. For example, an arcuate zone that includes Lakes Ontario and Erie extends from the St. Lawrence Valley to the west border of Michigan. It corresponds approximately to part of a predicted zone of brittle deformation caused by the Pleistocene ice load. The highlands of the western United States exhibit a blocklike outline to the north and east, being delimited by a boundary extending from south central Texas to northeast Iowa and thence west to the Olympic Peninsula of Washington. The east boundary is the dividing line between typical eastern and western topographic expression; it is also the approximate location of seismicity associated with the Nemadji uplift. The central and southern Appalachians show a surprisingly angular outline, particularly in contrast to the Appalachian features of the northeast. Much of the complex structure of the west coast of the United States is clearly depicted. Analyses of terrain data of the eastern United States suggest a correlation between regions of seismicity and certain of the terrain features.

The scale of the map that is shown is approximately 1:30,000,000. Terrain maps compiled at scales as large as 1:1,000,000 show many smaller features, usually extensive linear trends or areas of terrain of distinctive morphology. These features are thought to be surface expressions of underlying geologic structures. The digital terrain data are a new and virtually unexploited information source and should be useful in a wide variety of earth science investigations. (Photo courtesy of the U.S. Department of Defense.)

STREX: Winter Storm Study in Gulf of Alaska
U.S. and Canadian investigators are probing the initial stages of the large storms that dominate North American winter weather. In a study called STREX (Storm Transfer and Response Experiment), researchers aboard ships and aircraft are examining how energy and water vapor feed from the ocean to the atmosphere. This action fuels the large storms that rage across the Gulf of Alaska. The low-pressure systems drift ashore in western Canada and the Pacific Northwest, break up over the Rockies, and then reform into major systems that control winter weather from Canada to Texas.

It is believed that new insights into such disturbances will improve weather predictions and lead to a better understanding of the North American climate. The experiment is managed by the National Oceanic and Atmospheric Administration's Pacific Environmental Service. A STREX project office in Seattle will be used to coordinate the 6-week study. (Other STREX participants include the National Science Foundation, National Center for Atmospheric Research, National Aeronautics and Space Administration, U.S. Air Force, Office of Naval Research, U.S. and Canadian Coast Guards, Canada's Institute for Ocean Sciences, and Oregon State University.)

tion can deliver the spacecraft to the selected point in the target plane with an accuracy of ± 80 km (1 σ); the most optimistic estimate of delivery accuracy without onboard navigation is ± 500 km (Giotto). With optical navigation, it is thus possible to make sure the spacecraft passes through the zone of parent molecules which extends $\sim 10^3$ km from the nucleus, on the sunlit side, at a great enough distance to avoid smear in the highest resolution pictures.

The Halley Interceptor spacecraft (see figure) has a total mass of ~ 1800 kg, of which 300-400 kg will be allotted to the dual shield and ~ 125 kg to the science payload. A possible science payload is summarized in the table.

Halley goes through perihelion (0.6 AU) on February 9, 1986. A major advantage of the Halley Interceptor Mission is that it can intercept the comet either before or after perihelion.—PMB

Earth Radiation Budget Satellite

A satellite to measure the earth's radiation budget is to be integrated, tested, and delivered ready for launch on the space shuttle by April 1984. Although there have been Earth radiation budget instruments in NASA's experimental Nimbus 6 and 7 spacecraft, this will be the first time this factor can be measured on a global basis over a 24-hour day. The earth absorbs more solar energy in some regions and emits more thermal energy in others. This heating differential sets wind and ocean currents in motion to transfer heat from heated to cooled areas. Hence, the earth's radiation budget, as a driving force for weather, is one of the factors on which comprehensive data are needed for better weather and climate predictions.

The satellite, with its Earth Radiation Budget Experiment instruments, will become part of a three-spacecraft system, with NOAA-F and -G, to use scanning and non-scanning radiometers to measure the amount of solar radiation received and given up by different regions of the earth. The satellite will include systems for power, command and data handling, attitude control (three-axis stabilized), orbit adjust, as well as a thermal control. The spacecraft will communicate via the Tracking Data and Relay Satellite System. After launch by the space shuttle, the satellite will boost itself into a 600-km (373-mile) circular orbit, inclined 48° to the equator.

The Bell Aerospace Systems Division of Bell Corp., Boulder, Colorado, will provide the Earth Radiation Budget Satellite as well as its mission operations support. The contractor's proposed estimate of this cost-plus-award fee contract is approximately \$21 million.—PMB

Status of Voyager Spacecraft: Update

	Voyager 1	Voyager 2
Spacecraft distance from Earth, km	1,449,237,000	1,194,439,000
Spacecraft distance to Saturn, km		221,532,000
Spacecraft distance traveled since launch, km	2,294,300,000	1,964,094,000
Spacecraft velocity relative to Earth, km/s	28.9	20.5
Spacecraft velocity relative to sun, km/s	21.5	19.4

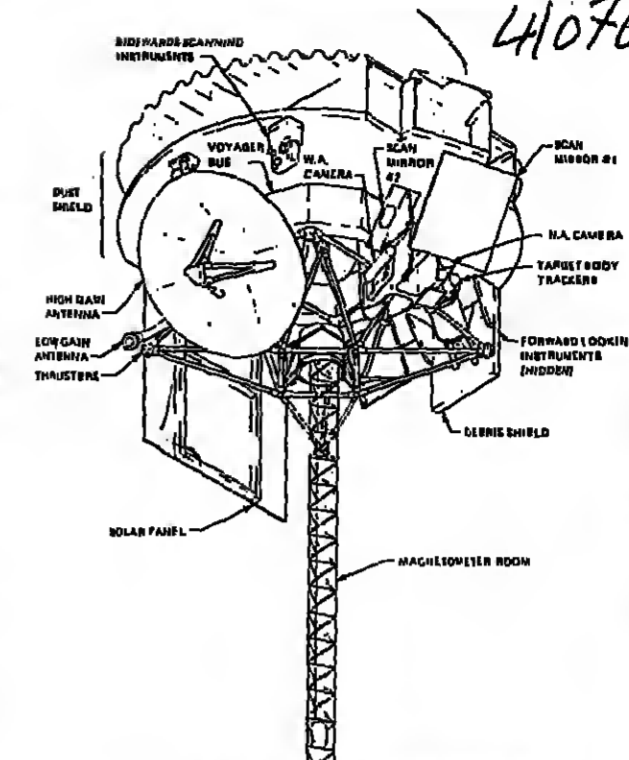


Fig. 1. The Halley Interceptor Mission spacecraft.

These aims lead to a number of practical requirements on any mission to Halley:

- (1) Accurate targeting of the spacecraft to a preselected point within the zone of parent molecules next to the nucleus.
- (2) Good imaging of the nucleus.

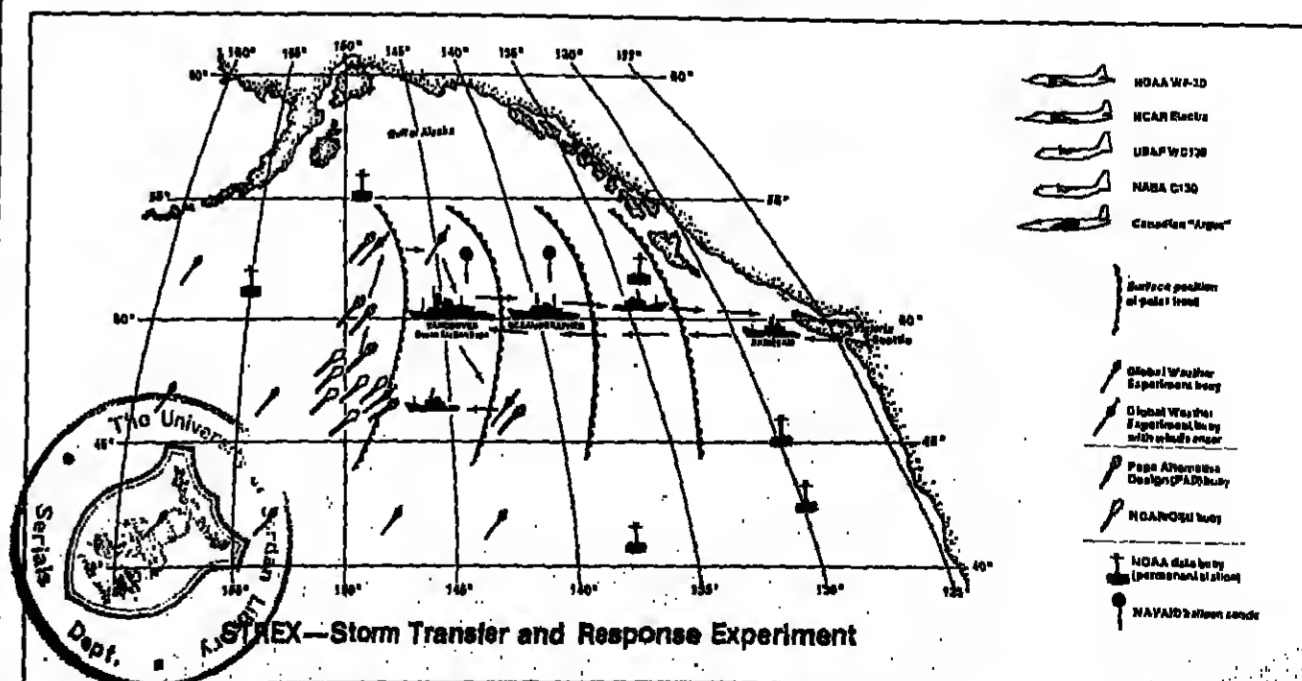
(3) An 'observatory phase' during which imaging of the tail and coma at progressively increasing spatial resolutions will be obtained.

- (4) Sufficiently long observation time for in situ measurements to cover the full 10^3 -km scale of phenomena at Halley.

The Halley Interceptor Mission is based on a three-axis-stabilized spacecraft. This allows significantly better imaging than can be achieved with most spinning spacecraft. A framing camera on a fixed-attitude spacecraft is the best means of achieving an observatory phase during which sequences of pictures are taken of the comet's tails and extended coma. Furthermore, with a framing camera, onboard optical navigation can deliver the spacecraft to the selected point in the target plane with an accuracy of ± 80 km (1 σ); the most optimistic estimate of delivery accuracy without onboard navigation is ± 500 km (Giotto). With optical navigation, it is thus possible to make sure the spacecraft passes through the zone of parent molecules which extends $\sim 10^3$ km from the nucleus, on the sunlit side, at a great enough distance to avoid smear in the highest resolution pictures.

Halley Interceptor Mission Typical Payload

Instrument	Mass, kg	Power, W	Data, kbps
Neutral mass spectrometer	8	5	2
Ion mass/velocity spectrometer	7	11	3
Electron analyzer	4	3	2
Magnetometer	3	5	1
Plasma wave analyzer	4	7	1
Dust composition analyzer	11	12	3
Dust counter	3	3	1
Remote sensor	12	8	2
Subtotal	50	54	15
Imaging	79	39	80
Total	129	92	105



STREX: Winter Storm Study in Gulf of Alaska

U.S. and Canadian investigators are probing the initial stages of the large storms that dominate North American winter weather. In a study called STREX (Storm Transfer and Response Experiment), researchers aboard ships and aircraft are examining how energy and water vapor feed from the ocean to the atmosphere. This action fuels the large storms that rage across the Gulf of Alaska. The low-pressure systems drift ashore in western Canada and the Pacific Northwest, break up over the Rockies, and then reform into major systems that control winter weather from Canada to Texas.

It is believed that new insights into such disturbances will improve weather predictions and lead to a better understanding of the North American climate. The experiment is managed by the National Oceanic and Atmospheric Administration's Pacific Environmental Service. A STREX project office in Seattle will be used to coordinate the 6-week study. (Other STREX participants include the National Science Foundation, National Center for Atmospheric Research, National Aeronautics and Space Administration, U.S. Air Force, Office of Naval Research, U.S. and Canadian Coast Guards, Canada's Institute for Ocean Sciences, and Oregon State University.)

During the experiment, research ships, aided by buoys deployed in the path of the storm, will take measurements from below the sea surface to thousands of feet in the air. Also, research airplanes will probe the advancing storm fronts. As many as 10 storms should cross the Gulf of Alaska during the experiment, which ends in mid-December.

STREX goals include improved weather forecasts and

Sedimentary Petrologist. The Geology Department at the University of Vermont is seeking a sedimentary petrologist for a tenure track position at the assistant professor level. Research and teaching specializations should be in classic sedimentary petrology with potential ancillary interests in petrology, geochemistry, and hydrology. It is expected that the successful candidate will establish a field-oriented research program which includes supervised graduate (M.S.) and undergraduate students. A Ph.D. is required and teaching experience is highly desirable. The Geology Department at the University of Vermont has a seven member department having an M.S. program and a definite commitment to excellence in undergraduate education. Applications will be accepted until April 1, 1981.

Candidate should send a resume and arrange for three letters of reference to be sent to:
John C. Oreke
Acting Chairman
Department of Geology
University of Vermont
Sunderland, Vermont 05405
The University of Vermont is an equal opportunity/affirmative action employer.

Yale University, Department of Geology and Geophysics. Applications are solicited for a faculty position in solid earth geophysics to begin in the academic year 1981-1982. Areas of interest to the department include seismology, exploration geophysics, mechanical and physical properties of rocks and minerals, geomagnetism, and tectonophysics. Yale University is an equal opportunity/affirmative action employer and encourages women and members of minority groups to compete for this position. Curriculum vitae, publications, and the names of three or more referees should be sent by January 31, 1981, to Robert R. Gordon, Chairman, Department of Geology and Geophysics, P.O. Box 6666, New Haven, CT 06511.

Sedimentary or Low Temperature Geochemist. This is an assistant professor, tenure track position, offering exceptional candidates of higher rank will be considered. We are looking for a geochemist to complement our strong programs in sedimentology, hydrogeology, organic geochemistry, and basin analysis. The teaching load is three courses per year—one beginning level geology course, an upper level geochemistry course, and a graduate course of his/her choosing. Introductory geology and summer field camp are also taught on a long-term rotating basis. A well-equipped laboratory and computer facilities are available. The position exists both for outside funding and for cooperative research.

The successful candidate will be expected to conduct an active research program leading to publications. Applicants should submit a letter of application, resume, a copy of each transcript, and have three supporting letters sent to:

Chairman
Department of Geology
University of Missouri
Columbia, Missouri 65211
The University of Missouri is an equal employment opportunity employer.

Postdoctoral Fellowships/Department of Terrestrial Magnetism, Carnegie Institution of Washington. Endowed postdoctoral fellowships in private institution, emphasizing maximum freedom of research in areas of geophysics, isotope and trace element geochemistry, mass spectrometry, planetary and solar and planetary formation. Renewable for second year. Woman and minority candidates encouraged. Completed applications due March 1, 1981. For information write Fellowship Committee, Dept. of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Road, N.W., Washington, D.C. 20015.

Associate Program Director/NSF. The National Science Foundation's Division of Earth Sciences is seeking qualified applicants for associate program director, Geophysics Program. This position is equivalent to GS-13/14, \$32,048-\$49,229 per annum, and will be filled on permanent or 2-year rotational basis. A Ph.D. in geophysics is desirable. Equivalent research and experience in the administration of large, multidisciplinary research programs may be substituted for a degree. A broad general knowledge of geophysics research and familiarity with the U.S. scientific community are also required. Applicants should submit a statement of interest and resume or SF-171, Personal Qualifications Statement to the National Science Foundation, Personnel Administration Branch, Announcement Number EX-80-21, Rm. 212, 1800 G St., N.W., Washington, DC 20550. Attn: E. Paul Broglie. Telephone: 202/357-7841.

NSF is an equal opportunity employer.

Graduate Assistantships/Physics and Astronomy. Graduate research assistantships and teaching assistantships in the Department of Physics and Astronomy of the University of Iowa are available to well-qualified students. The department has vigorous research programs in space physics, plasma physics, astrophysics, astrophysics, laser physics, atomic physics, nuclear physics, and solid state physics. Assistantships can begin in June, August, or January. Please address your inquiry to Department of Physics and Astronomy, The University of Iowa, Iowa City, IA 52242.

Sedimentary Geochemist. Princeton University seeks applicants for an assistant professorship within the general fields of the chemistry of sedimentary systems or the genesis/diagenesis of sedimentary rocks. Further information may be obtained from David Crerar, 609-452-4123.

Submit applications, including vita, statement of research and teaching interests, and names of three references to:

Sheldon Judson, Chairman
Department of Geological and Geophysical Sciences
Princeton University
Princeton, NJ 08544
Princeton University is an equal opportunity/affirmative action employer.

Chairperson. The Geoscience Department, New Mexico Institute of Mining and Technology, is seeking a geoscientist of recognized academic and scientific achievement for the position of chairperson. The Geoscience Department currently has degree programs through the Ph.D. in the fields of geochemistry, geology, geophysics, and hydrology. Candidates are expected to administer the department, conduct research, supervise graduate students and instruct in areas of interest. Ph.D. required, salary and rank open. Letter of application, resume and letters of three references should be postmarked prior to January 25, 1981 and sent to John R. MacMillan, Chairman of Search Committee, Geoscience Department, New Mexico Tech Socorro, NM 87801.

AA/EOE.

Assistant Professorship/Department of Physics, University of Minnesota. We expect to fill a tenure track position at the assistant professor level during the next two years. Priority will be given to candidates in space physics. Applicants will be judged in terms of their promise for outstanding scholarship in their research areas, promise for excellence in teaching, and the relationship of their research programs to programs of the department. Candidates should send a resume, bibliography, and statement of research interests to:

Professor Walter Waymire, Head
Department of Physics
University of Minnesota
118 Church Street, S.E.
Minneapolis, Minnesota 55455

The candidate should arrange to have at least three letters of recommendation sent directly to the above address. The deadline for receipt of all material is February 1, 1980.

The University of Minnesota is an equal opportunity employer. The University specifically invites and encourages applications from women and minorities.

Computer Specialist/University Research Environment. The University of Rhode Island is seeking an individual to help implement a Satellite Remote Sensing Software Package on our PRIME Computer System. Applicant should be trained in working in a dynamic research environment and must be capable of managing his/her own time and of seeing a project through from start to finish. Applicant must be available immediately.

The ideal candidate will have a working knowledge of PRIME and DEC RSX-11 FORTRAN, operating system subroutines and Assembly Language, experience with satellite remote sensing systems or image processing systems and a degree in computer science or software engineering. Applicants with an appropriate subset of the above skills will be considered.

Salary range is \$18,310 to \$22,310. Benefits include 22 days vacation and a rural ocean side setting in which to enjoy the life.

Color send resume before January 1, 1981 to: Al Cutting, Graduate School of Oceanography, Computer Center South Fair Rd., Narragansett, Rhode Island 02882

(401) 782-9266

An affirmative action/equal opportunity employer M/F

Faculty Positions Astronomy/Space Physics. The Department of Astronomy of Boston University invites applications for one or two tenure track faculty positions opening September 1981. Emphasis will be placed on active research experience as well as interest in graduate and undergraduate teaching. We are considering good candidates from any field of astronomy or space physics. Applicants should send resumes and the names of three references to M. C. Papaioannu, Department of Astronomy, Boston University, Boston, MA 02215.

Boston University is an equal opportunity employer.

Postdoctoral Research Associate/Mineralogy. Applications are invited for research in high resolution and analytical transmission electron microscopy of minerals and their analogues. Experience in crystallography, x-ray diffraction, or electron microscopy is desirable. Send resume (including transcripts), statement of research interests, and names of three references to P. R. Buseck, Department of Geology, Arizona State University, Tempe, AZ 85281.

Arizona State University is an EEO/AA employer.

Geophysics Research Associate. Western Observatory of Boston College seeks M.S. in geophysics (doctorate work desirable), familiarity with time and frequency domain analytical techniques and knowledge of FORTRAN programming. Opportunity for independent research along with assigned responsibilities relating to New England seismic network. Salary to \$20,000 depending on qualifications and excellent benefits. Send letter and resume to Diane Rogers, Associate Director of Personnel, Boston College, 140 Commonwealth Avenue, Chestnut Hill, MA 02187.

An equal opportunity/affirmative action employer

Exploration Geophysicist/University of Oklahoma. As part of a 5-year plan of development and expansion, the School of Geology and Geophysics is looking for a person to join the nucleus of an exploration geophysics group. A Ph.D. in geophysics is required, and preference will be given to someone whose teaching and research interests are in the acquisition, processing, and/or interpretation of seismic data. Present equipment includes a truck-mounted thumper energy source, capable of penetrating a kilometer or more of rock; a portable, 12-channel seismic recording system; gravimeters, magnetometers, an electrical resistivity unit; a seismic microcomputer, and terminals to the University's IBM 370 system. A geophysical observatory supports research in solid earth geophysics, and the exploration geophysicist would work closely with the tectonic solid earth geophysicist group.

Applications are due February 15, 1981. Salary is competitive with industry standards. Inquiries and applications should be sent to John Wickham, Director, School of Geology and Geophysics, University of Oklahoma, Norman, OK 73019.

The University of Oklahoma does not discriminate on the basis of race or sex and is an equal opportunity employer.

Faculty Position. The Department of Geology of the University of New Mexico seeks applicants for a position in clay mineralogy, low-temperature geochemistry, carbonate petrology, or economic geology. The appointment may be at the assistant, associate or full professor level contingent on approval of funding. The successful candidate will be expected to be committed to teaching at both the undergraduate and graduate levels. In addition, he or she will be expected to develop a vigorous research program in his or her field of specialty and will be expected to supervise graduate students at the M.S. and Ph.D. levels. The closing date for application is April 15, 1981. Applicants should send a resume, curriculum vitae, and a brief discussion of research interests to Rodney C. Ewing, Chairman, Department of Geology, University of New Mexico, 87131.

The University of New Mexico is an equal opportunity/affirmative action employer.

Virginia Polytechnic Institute and State University. Igneous Petrology and Geochemistry/Research Associate. Origin and tectonic significance of granitic rocks. Project involves petrography, analytical chemistry, mineral chemistry, isotopic studies, and field mapping. Send resume to: O. R. Warner, Chairman, Department of Geological Sciences, Virginia Poly. Inst. and St. Univ., Blacksburg, VA 24061

The University is an equal opportunity/affirmative action employer.

Program Manager/Meteorology. Oceanographic Services, Inc. is seeking a qualified applicant for the position of program manager for meteorological studies. Applicant should have an M.S. or Ph.D. in meteorology or atmospheric sciences, plus experience in the field. A broad knowledge of oceanology, of pollution, and an understanding of the air pollution regulatory environment, is helpful. Interested persons should send resume, references, and salary history to R. C. Banks, Oceanographic Services, Inc., 25 Cassillon Ave., Gaithersburg, MD 20878.

Resource/General Geologist. The University of Pittsburgh at Bradford will have a tenure track opening for a resource or general geologist in September, 1981. This new position will serve an established two-year program in petroleum technology and a new, geology-based, four-year program in environmental sciences. Rank and salary are negotiable. The candidate will be expected to teach introductory and petroleum geology and at least some of the following courses in the earth and environmental sciences program: structural geology, stratigraphy, economic geology, coal geology. In addition, the candidate will teach courses in the petroleum technology program that are compatible with his or her skills. A Ph.D. and some experience are required, but applicants with solid academic backgrounds will be considered. Preference will be given to those with petroleum industry experience.

Bradford is located in the Allegheny Mountains in an area rich in natural and recreational resources. Please send resume and three letters of reference to Carl Burghardt, University of Pittsburgh at Bradford, Bradford, PA 16701.

The University of Pittsburgh is an equal opportunity/affirmative action employer.

Seismologist. The State University of New York at Binghamton has a vacancy for a seismologist at the assistant professor level. Candidates with research interest in exploration geophysics or earthquake seismology and a solid theoretical background are encouraged to apply. A Ph.D. with 0 to 5 years of teaching, research, and/or industrial experience is appropriate for the position. Salary is negotiable and competitive with academic institutions. Positions are available in fall 1981. Please send resume and the names of three references to Chairman, Geophysical Search Committee, Department of Geological Sciences, State University of New York, Binghamton, NY 13901.

State University of New York at Binghamton is an affirmative action/equal opportunity employer.

Structural Geologist. The Department of Geosciences of Purdue University invites application for a tenure track faculty position in structural geology, starting in August 1981. Rank and salary will be commensurate with qualifications. A Ph.D. is required. The individual will be expected to teach undergraduate and graduate courses in structural geology and tectonics, participate in summer field courses, and pursue an active research program. Preference will be given to a candidate with an applied field orientation and a strong background in the quantitative analysis of field data. The department has active programs in petrology, geophysics, and engineering geology and has a close working relationship with the geotechnical group in civil engineering and the Laboratory for Applications of Remote Sensing. Closing date for application is April 1, 1981. Applicants should send a resume, the names, addresses, and telephone numbers of three references, and a brief statement of research interests to R. H. McCollister, Department of Geosciences, Purdue University, West Lafayette, IN 47907.

Purdue University is an equal opportunity/affirmative action employer.

University of New Orleans/Geophysicist. Applications are invited for a permanent faculty position commencing August 1981. In exploration geophysics. The Ph.D. or equivalent experience is required.

Appointees will be expected to teach graduate and undergraduate courses in geophysics and general geology, conduct a program of research, supervise graduate students, and participate in departmental activities. Work with structural geologists and applied meteorologists. Rank and salary open. Send resume and the names of three references to Richard H. Orosch, Civil Service Commission, P.O. Box 3808, Tulsa, OK 74102.

An equal opportunity employer M/F.

UNO is an equal opportunity/affirmative action employer. Applications from minority groups are specifically invited.

Geophysicist/University of South Carolina. The University of South Carolina anticipates a new faculty appointment in geophysics for 1981, subject to adequate legislative funding. We are especially interested in individuals who have experience in the fields of exploration geophysics, seismic interpretation, or solid earth geophysics. This would be a 6-month, tenure track position at the assistant or associate professor level, beginning August 1981. Some start-up funds are available for major equipment purchases. The individual who fills this position would join the growing geophysical component of the Geology Department, which currently emphasizes seismology, regional tectonics, and paleomagnetism, and would develop an aggressive research program in his or her specialty.

Please send vitae and names and phone numbers of three individuals we may contact for references to: William S. Moore, Chairman, Search Committee for Geophysics, University of South Carolina, Columbia, SC 29208. Closing date for this announcement is March 15, 1981.

The University of South Carolina is an affirmative action/equal opportunity employer.

Meteorologist and Hydrologist/Saudi Arabia. The School of Renewable Natural Resources, University of Arizona, invites applicants for assignment as faculty members to the Institute of Meteorology and Arid Land Studies, King Abdulaziz University, Jeddah, Saudi Arabia. One year, renewable positions in meteorology and hydrology are available.

1. Ph.D. in meteorology with experience in undergraduate teaching and research. Curriculum includes courses in meteorological instruments and methods of observation, dynamic meteorology, synoptic meteorology, physical meteorology, and climatology.

2. M.S. in meteorology with practical experience in meteorological operations and undergraduate teaching. Knowledge of WMO procedures.

3. Ph.D. in a hydrologic science or engineering with experience in undergraduate teaching and in research. Major emphasis will be in the areas of surface and groundwater development, water management in arid environment and in evaluating the hydrologic effects of development.

Description: This project is funded by the Saudi Arabian government through the U.S.-Saudi Arabian Joint Commission on Economic Cooperation. Administrative and logistic support is provided by the U.S. Treasury Department, while the project's implementation is by a contract with the Consortium for International Development. The goal of the project is to undertake technical cooperation to develop educational programs for meteorology, hydrology, and arid land studies and environmental protection.

Salaries and allowances: Highly competitive with 25% overseas adjustment, housing, car and other allowances.

Availability: February 1, 1981, or soon thereafter for spring semester; September 20, 1981, for fall semester. Initial appointment of one year or more contingent on performance.

Closing date: January 15, 1981 for spring semester; February 15 for fall semester.

Application: The application should include the following: (a) a letter detailing principal qualifications and interests; (b) a curriculum vitae; (c) name, address and telephone numbers of three references. Send to: Martin M. Fogel, Director, CID/King Abdulaziz University Project, 317A Anthropology Building, University of Arizona, Tucson, AZ 85721, Telephone (602) 826-5344/2888.

EO/AA Employer.

Hydrogeologist. The State University of New York at Binghamton invites applications for a permanent position in groundwater hydrology, starting fall 1981. It is desirable that applicant have teaching and research interests in one or more of the following: groundwater hydrology, modeling, flow through porous media, and environmental hydrogeology. However, applicants with interests in other areas will be considered.

Teaching responsibilities will include both undergraduate and graduate courses. The opportunity exists to initiate courses at all levels, but development of one lower-level undergraduate course is essential. Research facilities include: electron microscope, scanning electron microscope, X-ray diffractometer, atomic absorption and transmission spectrophotometers, and access to a large central computer as well as microcomputer in department. Appointment is planned as assistant professor, but not necessarily at beginning level. Salary is negotiable, but will be at competitive academic level.

Applicants should submit resume and arrange for three letters of recommendation to be sent to James E. Soroul, Chairman, Department of Geological Sciences, State University of New York at Binghamton, Binghamton, NY 13901.

State University of New York at Binghamton is an affirmative action/equal opportunity employer.

CITIES SERVICE COMPANY

Research Opportunities

Research position in structural geology emphasizing the structural interpretation of seismic reflection profiles, using the latest seismic processing techniques to interpret complex structures. Work with structural geologists and applied meteorologists. Rank and salary open. Send resume and the names of three references to Richard H. Orosch, Civil Service Commission, P.O. Box 3808, Tulsa, OK 74102.

An equal opportunity employer M/F.

UNO is an equal opportunity/affirmative action employer. Applications from minority groups are specifically invited.

Synoptic/Dynamic Meteorology. Description: The Geophysical Institute and Observatories, University of Alaska, invite applications from qualified scientists for a full-time (12-month) faculty position at the Assistant or Associate Professor level. The successful candidate will be expected to prepare and submit research proposals to external agencies and to work cooperatively with ongoing research programs. He/she will be also expected to teach occasional courses in synoptic/dynamic meteorology at the upper division and graduate level.

Qualifications: Ph.D. in meteorology. Research experience in advanced analysis and diagnostic studies of global-scale meteorological processes is essential, preferably over the full height of the atmosphere (0-100 km). Preference will be given to applicants who can utilize their expertise in synoptic/dynamic meteorology to synthesize the results of various ongoing research projects in mesoscale and large-scale meteorology, cloud physics, radiation, aeronomy, and space physics into a better understanding of the large-scale meteorology of the North Pacific and polar regions. Teaching experience of the undergraduate and graduate levels is desirable.

Salary: Upward to \$34,600 (Asst. Prof.) or \$43,300 (Assoc. Prof.) per year, dependent upon qualifications and experience.

Applications: For further information, including recent annual research report, write to Director, Geophysical Institute, University of Alaska, Fairbanks, AK 99701. Closing date for applications is February 28, 1981.

The University of Alaska is an equal opportunity/affirmative action employer.

Meetings

Space Science Perspectives

The National Air and Space Museum will sponsor a free symposium, entitled "Space Science Comes of Age: Perspectives in the History of the Space Sciences," on March 23-24, 1981. Included in the symposium will be discussions of solar astronomy from space, high-energy astronomy, lunar geology, ionospheric research, launch systems technology, and a history of LANDSAT.

For additional information, contact the National Air and Space Museum in Washington, D.C. ☐

Ocean Energy Conference

Abstracts for papers to be considered for the 8th Ocean Energy Conference, sponsored by the Department of Energy, are due January 20. The conference, scheduled for June 7-11 in Washington, D.C., has as its theme "Ocean Energy: Meeting the National Goals."

Papers dealing with systems orientation, industry involvement, new concepts, development planning emphasis, and technology/cost benefit projections are particularly desired. Papers stressing new and significant advances or concepts in materials, devices, or techniques relevant to ocean energy are also welcome.

Abstracts, limited to a maximum of 400 words, should be sent to Technical Committee Chairman, 8th Ocean Energy Conference, Marine Technology Society, Suite 412, 1730 M Street, N.W., Washington, D.C. 20036. ☐

Hellenic Arc and Trench Symposium

An international symposium on the Hellenic arc and trench will be held at the National Technical University in Athens, Greece, April 8-10, 1981. The formation and evolution of the arc and trench from land- and sea-based studies and the relation to the tectonics of adjacent areas will be the symposium's focus.

Comparisons with similar geotectonic structures, including the Tyrrhenian Sea and Pannonian Basin, will be made. Results of new oceanographic and space techniques and discussion of deep lithospheric and asthenospheric processes responsible for the dynamics of the area will be emphasized.

For additional information, contact Xavier La Pinchon, Director, Geodynamics Laboratory, Académie de Paris, Université Pierre et Marie Curie, 4 Place Jussieu, Tour 15, Premier Etage, 75230 Paris. ☐

Senior Position in Earth Science

The Earth Sciences Division of the LAWRENCE BERKELEY LABORATORY has several comprehensive research programs involving the earth sciences. An opening exists for a person with an established national reputation in a scientific discipline in Earth Sciences, preferably geomechanics or hydrogeology, to assume a position of responsibility for the scientific leadership and direction of major research programs such as concerned with radioactive waste storage.

Outfit will include looking the scientific initiative and direction and management of ongoing projects, including the nuclear waste isolation field involving more than 30 scientists and engineers at LBL and collaborative work with several academic and research organizations. Additionally, the position involves establishment of emerging programs, expansion of research facilities and pursuit of new areas of investigation.

The successful candidate should have extensive experience and proven capabilities in directing and achieving programmatic goals of complex research projects involving teams of senior scientists and engineers. A Ph.D. in a field of the Earth Sciences is preferred with significant applicable experience. Salary: over \$50k.

Applications will be considered no later than April 1, 1981. Interested individuals should forward two resumes including salary history to: Employment Office, LAWRENCE BERKELEY LABORATORY, One Cyclotron Drive, Berkeley, CA 94720. An equal opportunity employer M/F.

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qualifications and experience.

Applications: For further information, including recent annual research report, write to Director, Geophysical Institute, University of Alaska, Fairbanks, AK 99701. Closing date for applications is February 28, 1981.

The University of Alaska is an equal opportunity/affirmative action employer.

Hydrogeologist. Applications are invited for a research position in hydrology, M.S. in hydrology or geology required, Ph.D. preferred. A minimum of 2 years experience related to water-air heat pumps, aquifer evaluation for heat pump application, and general groundwater hydrology. Position involves evaluation of Montana's aquifers for heat pump use. Send resume, copy of college transcripts, and three letters of reference to E. C. Singler, Deputy Director, Montana Bureau of Mines and Geology, Montana Tech, Butte, MT 59701, by February 1, 1981.

An equal opportunity/affirmative action employer.

Ocean Dynamist. An academic position (tenure-seeking track) for an ocean dynamist is presently available in the Department of

Oceanography, Naval Postgraduate School (NAPVPGSOL). Present at ultimate research interest in area of naval oceanographic concern is desirable. Such areas include: ocean circulation modeling, especially prognostication on the oceanic synoptic scale; surface and internal gravity wave dynamics; synoptic analysis of oceanic data; and coastal oceanography. The candidate should be willing and able to teach a variety of graduate courses in physical oceanography and related topics. The NAPVPGSOL has excellent computer, data archive, library, and research vessel facilities. The Department of Oceanography has close relations with the Fleet Numerical Oceanography Center, Naval Environmental Prediction Facility, and the Naval Laboratory. The department has a faculty of fifteen and a student body of 80 to 100. The overall emphasis is ocean prediction with present faculty and student research in coastal ocean, polar ocean, and air-sea interaction processes. The academic and research programs are conducted in close collaboration with the Department of Meteorology and Physics. Salary will be determined by qualifications of the successful candidate. By January 1 if possible, send a curriculum vitae, the names and addresses of three references, and a statement of research and instructional interests to:

Faculty Search Committee, Department of Oceanography, Naval Postgraduate School, Monterey, CA 93940. Visits by top candidates will be scheduled soon after. A decision will be attempted by March 1 and the position should be occupied by about June 1, 1981.

The Naval Postgraduate School is an equal opportunity employer.

COURSES

Call for Papers. Third International Ocean Drilling Symposium, October 18-19, 1981. Alfred C. Redfield Auditorium, Woods Hole Oceanographic Institution, Woods Hole, MA 02543.

For abstract and manuscript requirements, accommodations, student travel awards, and other inquiries contact:

Dr. W. C. Cullen, Symposium Chairman
Marine Sciences Research Center
State University of New York at Stony Brook
Stony Brook, New York 11794

9th Caribbean Geological Conference

The ninth in a series of Caribbean Geological Conferences, which are held every 3 or 4 years, took place in Santo Domingo, capital of the Dominican Republic, from the 15th to 26th of August 1980. The conference, which was sponsored by the government of the Dominican Republic and the Universidad Católica Madre y Maestra, was preceded by 2 days of field trips and was opened by President Antonio Guzmán on the evening of the 17th of August. Generous support was provided by Aloce Exploration Co., Falconbridge Dominicana, and Rosario Dominican.

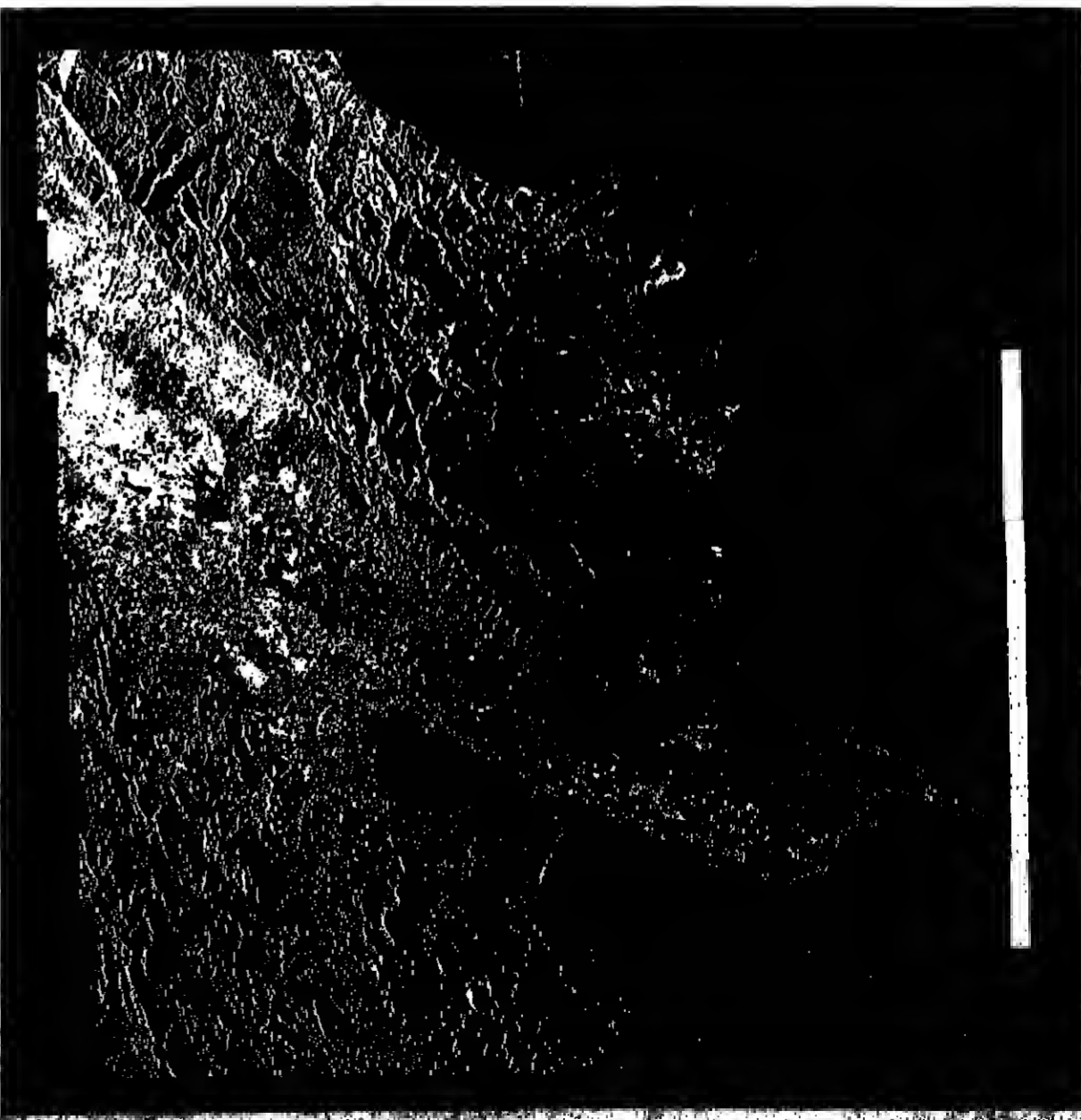
Geologists and geophysicists from 25 countries presented about 130 papers on a wide variety of topics ranging from geophysics to paleontology. While the whole Caribbean area was discussed, there was special emphasis on the northern Caribbean and Hispaniola, as befitted the site of the conference. The contribution of workers from the Dirección General de Minería was particularly notable.

Much of the structure, geophysics, and petrology sessions was directed toward attempting a clearer understanding of the tectonic development of the Caribbean region. Most papers concentrated on the geomorphic, geophysical, and geological constraints rather than on comprehensive models. A

panel discussion on the tectonics of the northern Caribbean summarized the widely differing opinions on the development of that particular region.

There seemed to be a general consensus of opinion that the tectonics of the northern and southern boundaries of the Caribbean plate are dominated by zones of simple shear, with localized compression related to the eastward movement of the plate in relation to North and South America. New evidence from Jamaica and Hispaniola demonstrated that this is a wide zone (at least 200 km), as in the southern boundary. However, the time of initiation of this deformation is still somewhat obscure.

Other than agreement that the pre-Tertiary tectonic pattern must be constrained by the relative positions of North and South America throughout Jurassic and Cretaceous times, little consensus of opinion on the earlier development of the Caribbean was reached. There was agreement that the systems dominated, but there was much discussion on the age, number, relative positions, and polarity of Cretaceous island arcs. Despite a wealth of structural, petrological, and geochemical data on Cretaceous igneous and metamorphic rocks, including new data from Jamaica and Hispaniola, the



This satellite radar image of the northeastern Dominican Republic, on the island of Hispaniola, was acquired by NASA's Seasat satellite, which was built and managed by the Jet Propulsion Laboratory. The image is approximately 100 km on a side, and north is toward the upper right. The line through the image center is the result of a radar calibration pulse. Islands of the Greater Antilles group lie on the northern boundary of the Caribbean plate. Strike slip motion along this boundary is evident from major faults through the island of Hispaniola. Their trend is dominantly east-west, and in the image they strongly outline the Cibao Valley (upper left to lower right). Left lateral movement along the faults is suggested by offset drainage patterns, notably in the lower center of the image. Wave cut terraces in Pleistocene to recent carbonate near Cabo Francés Viejo (peninsula in the upper right) suggest that rapid uplift is also occurring along this portion of the plate boundary. (Photo supplied by T. H. Dixon, Radar Remote Sensing Team, Jet Propulsion Laboratory.)

nature of these arcs and their relation to modern arcs are still not clear. It became apparent (to this writer at least) that much could be accomplished by systematic isotopic studies on crystalline rocks to augment recent structural, stratigraphic, and petrological work.

The papers on geomagnetism, stratigraphy, and paleontology were mainly concerned with Hispaniola. Recent work by two French teams, one from the Institut Français du Pétrole and the other from the Université Pierre et Marie Curie, described thick Neogene sections in southern Hispaniola. These were interpreted as an equivalent of the underthrust sediments of the Muertos trough and as an Alpine-type lynch-mass sequence, respectively. Stratigraphic and sedimentological investigations and tectonic implications for other parts of southern Hispaniola were also described. Stratigraphic, sedimentological, and paleontological studies of Tertiary rocks in northern Hispaniola were also discussed. This included a major presentation of results of an interdisciplinary investigation of classic Neogene sections by an international team coordinated by geologists from the Naturhistorisches Museum, Basel. Considerable controversy was generated by a new interpretation of rocks of the Scotland district, Barbados, as shallow-water deposits. Another paper pointed out that Barbados was likely to have been much farther west and nearer South America during the time the rocks of the Scotland district were deposited.

The sessions on volcanology were dominated by discussions by a University of Puerto Rico team on the character and mechanisms of pyroclastic eruptions in the Lesser Antilles. However, there were other interesting papers that dealt with the tectonic framework of the Lesser Antilles, geothermal investigations in Martinique, and the 1979 eruption of Soufriere, St. Vincent. Also of note was the description of the very recent alkali volcanism in Hispaniola.

The economic geology section was one of the largest ever

at a Caribbean conference. The enigmatic Los Ranchos Formation in the Dominican Republic, which is the host of the western hemisphere's largest and oldest gold mine, was widely discussed, as was Caribbean metallogenesis, principally in Jamaica and Venezuela. Contributors from the Dominican Republic, Jamaica, and Venezuela also presented papers on petroleum and industrial minerals.

Marine geology has always figured prominently in the Caribbean Geological Conference, and at this meeting, highlights included French studies of the submarine geology of the Lesser Antilles Arc and Avea ridge which were complemented by a report on a deep test (Saba Bank No. 1) that bottomed in Paleocene andesite porphyry. Papers were presented on the paleomagnetism of both northern and southern margins of the Caribbean which confirmed the substantial rotations in both areas indicated by earlier studies. The general absence of magnetic anomaly signatures from the Venezuelan and Colombian basins, and the possibility that structures such as the Hessa ascarpments may be old fracture zones, were discussed. An assessment of the magnetic anomaly field of the Yucatan basin provides a useful basis for future research, and presentation of geoid anomalies of the Caribbean represented a contribution in a rapidly advancing field.

The conference was concluded by a stimulating (and demanding) 4-day field trip, which effectively presented a cross section of the geology of the Dominican Republic.

Further information, abstracts, and guidebooks can be obtained from 9th Conferencia Geologica del Caribe, Apartado 2719, Santo Domingo, Dominican Republic.

This meeting report was prepared by Glen Draper, who is with the Department of Physical Sciences, Florida International University, Miami, Florida.

BERKNER MEMBERSHIPS Grants for Scientists in Developing Countries

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AGU members are encouraged to send names and addresses of such individuals to AGU so that applications and details can be forwarded. Current members are not eligible.

This program is a living memorial to Lloyd Berkner whose devotion to the encouragement of young scientists and stimulation of international activities will long be remembered.

Applications and further details are available from:

Member Programs Division
American Geophysical Union
2000 Florida Avenue, N.W.
Washington, D. C. 20009
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5140 Solar wind plasma
The magnetic field of the solar wind is based on the results of the Solar Wind Speed Variations Observed at Earth (SWE) mission. The mission was designed to study the solar wind and its interaction with the Earth's magnetosphere. The mission was designed to study the solar wind and its interaction with the Earth's magnetosphere. The mission was designed to study the solar wind and its interaction with the Earth's magnetosphere.

Particles and Fields— Ionosphere

1500 Aligned
The Aligned Ionosphere (AI) is a phenomenon that occurs in the ionosphere. It is characterized by a strong alignment of the magnetic field lines. The AI is observed in the ionosphere and is characterized by a strong alignment of the magnetic field lines. The AI is observed in the ionosphere and is characterized by a strong alignment of the magnetic field lines.

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Particles and Fields— Magnetosphere

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Honor Your Colleagues

The Walter H. Bucher Medal Committee

This committee, chaired by Bryan L. Hicks, is seeking nominations for the award, which honors the person who has made a significant contribution to the basic knowledge of the earth's crust.

Letters of nomination and supporting materials should be sent directly to the Department of Geological Sciences, Cornell University, Ithaca, New York 14850.

The citation and acceptance for the 1979 Bucher Medal, Edward Irving, were published in the August 14, 1979, issue of EOS. Previous recipients were:

1956 J. Tuzo Wilson	1972 William James Morgan
1960 James Oliver	1974 Maurice Ewing
1970 David G. Gough	1975 Lynn Sykes
1971 Robert S. Dietz	1977 Bruce C. Heezen

DEADLINE FOR NOMINATIONS IS JANUARY 15, 1981

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Hydrology

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[illegible]

SWAN (Interior of moon Hactoula, force fields, composition, etc.)
STRUCTURE OF THE LUNAR CRUST AT RICHMOND SITE
SPELLO STATION 15
Mud & Cores (Moon) Research and Development
Cor. P. O. Box 500, Dallas, TX 75221, Angus B. Dainton and M. Rafi Yohani
The seismic crust structure at the moon is known in the region of Ceresium Procellarum from the analysis of artificial impact data. To extend this knowledge we have used data from natural impacts to attempt to search for secondary animals were detected in the form of P-P-12g multiple aimed by calculations at present latitudes and converted multiple aimed by variations at thermal interphase. A polarization system has been applied to the data to enhance the results.

1970 structure of the crust and the constraints on the seismic wave velocity structure beneath the Tibetan Plateau and Yunnan Yunnan. *Chin. J. Geophys.* 13, 1-10.

W. P. Chen (Geoscientific Institute at Tsinghua University, 72 Xueshuibei Road, Cambridge, MA 02138) and J. H. Chen (Department of Earth and Planetary Sciences, Harvard University, 27 Oxford Street, Cambridge, MA 02138) discuss the seismic wave velocity structure beneath the Tibetan Plateau and Yunnan. They use a 3-D model of the crust and upper mantle to explain the observed seismic wave velocity structure. The model is based on the assumption that the crust is composed of a sequence of layers with different seismic wave velocities. The model is solved for the seismic wave velocity structure beneath the Tibetan Plateau and Yunnan. The results show that the seismic wave velocity structure beneath the Tibetan Plateau and Yunnan is consistent with the observed seismic wave velocity structure. The model also predicts the seismic wave velocity structure beneath the Tibetan Plateau and Yunnan for different crustal thicknesses and for different seismic wave velocities. The model is a good approximation of the seismic wave velocity structure beneath the Tibetan Plateau and Yunnan.

Cover. Photograph shows the sawn interior of a 7.9-kg meteorite (Elephant Morania 79001, recovered by the U.S. Antarctic expedition in 1979) and now part of the Antarctic meteorite collection being curated at the NASA-Johnson Space Center in Houston, Texas. The meteorite is apparently related to the shergottites, a rare group of achondrite meteorites comprising Shergotty, which fell in India in 1865; Zagami, which fell in Algeria in 1962; and Allan Hills 77005, recovered from the Antarctic in 1976. The relatively young ages of these three basaltic meteorites, less than 1.4 billion years, raise interesting questions as to whether these young ages date igneous events and, if so, whether that igneous activity took place in small bodies, such as the asteroid Ida, where plausible heat sources are proposed, or on one of the inner planets where volcanism may have persisted throughout most of solar history. Cooperative studies by several investigators will begin shortly on this new sample EETA 79001, which more closely resembles the shergottites than any other meteorite group. It is also uniquely known as the first Antarctic meteorite found in showing an apparently undisturbed growth of mineral inclusions in the pyroxene-rich matrix. The inset shows a detail of the photograph, and the plagioclase-melt breccia basalt at the right-hand margin. Dark areas within the sample are catchers and remnants of dark glass.

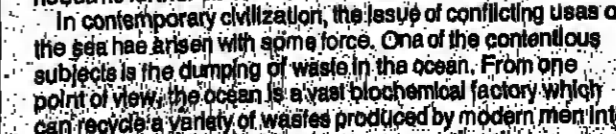
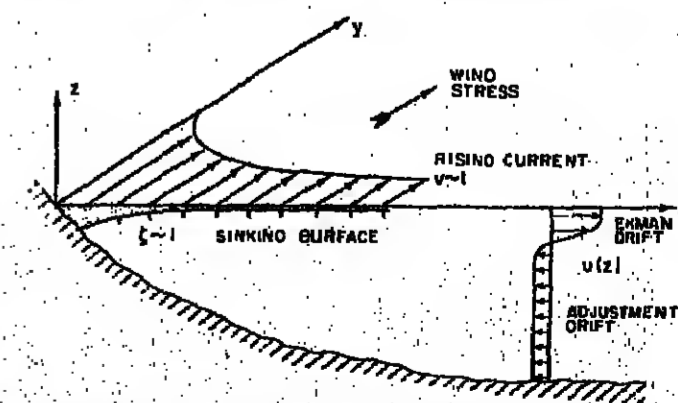


Fig. 2. Generation of coastal currents by longshore wind. Ekman drift in the surface layer onshore or offshore is compensated for by motions accompanying adjustment to geostrophic equilibrium. The fluid below the Ekman layer is accelerated in the longshore direction by the Coriolis force of (cross-shore) adjustment drift.



that predict some agreed measure of nuisance or hazard associated with a given waste disposal or similar operation. The development of such models is a task of engineering science, which is outside the scope of the present article. These models, however, require quantitative inputs from various sciences, including the physical oceanography of the coastal ocean. In particular, a solid body of knowledge of circulation and mixing processes which is widely accepted by the scientific community is required. Otherwise, extravagant claims cannot be easily refuted, and reason becomes overshadowed by doomsday philosophy. On a rational level, the knowledge of coastal ocean physics is a prerequisite for a comparison of the consequences of oceanic disposal with the consequences of alternative disposal strategies.

Wind-Driven Transient Currents

The prime driving force of circulation in the coastal ocean is the wind. This is not always obvious in tidal waters, but people living along the shores of the Great Lakes, for example, where tides are practically nonexistent, are well aware that wind action on coastal waters rapidly generates flow predominantly parallel to the coast. The coast prevents perpendicular movement, but longshore motion is unhindered and the longshore component of the wind is particularly effective in generating longshore currents and corresponding long particle displacements.

One of the fruits of recent field studies and associated theoretical work has been an understanding of the structure and dynamics of such wind-driven nearshore currents. Earlier ideas came mainly from pioneering theoretical studies, such as those of Ekman [1905], which were based on various idealizations and usually applied only to steady state frictional equilibrium flow. However, winds at mid-latitudes are variable, rarely remaining constant for more than a day. Under these circumstances the transient properties of coastal currents are often of greater practical importance than their asymptotic steady state for constant wind. These transient properties depend more on inertial forces than on frictional ones, a fact which makes the Ekman-type models of limited use.

Inertial effects may be simply understood with aid of simple models in which bottom friction is supposed absent and a longshore wind stress is suddenly imposed at the surface. Any persistent longshore motion that arises must somehow adjust to geostrophic equilibrium, i.e., the Coriolis force associated with longshore motion must eventually be balanced by an appropriate pressure field. Rossby [1938] first discussed such problems of 'geostrophic adjustment,' and Cherny [1955] extended Rossby's work to coastal current generation in a two-layer ocean of constant depth. In Cherny's quasi-geostrophic model, the accelerating longshore current is postulated to adjust continually to geostrophic equilibrium. In reality, this may be expected to be true for periods of order f^{-1} and longer ($f = \text{Coriolis parameter}$). More complete calculations for simple closed basin or coastal zone models confirm that the response of a modest size sea ($f = \text{constant}$) to sudden wind stress can be regarded as a superposition of a quasigeostrophic (developing) coastal current and various long waves.

The dynamical principles involved in quasigeostrophic longshore current generation that are elucidated by these theoretical studies are illustrated in Figures 2 and 3. The surface level perturbation and the longshore velocity increase hand-in-hand, maintaining geostrophic balance. In the longshore direction, the wind stress impulse equals the depth-integrated momentum of the water column, as long as bottom friction is negligible.

The simple momentum balance in the longshore direction between the applied force and the increase of momentum in the water column can hold in the coastal zone because the depth-integrated Coriolis force associated with cross-shore flow vanishes. This is a direct consequence of the 'coastal constraint', i.e., the condition that no water is transported in a direction perpendicular to the coast. The coastal constraint applies strictly to the coast, and to a high degree of approximation within some distance from the coast. The length of that distance is an important quantitative datum of each coastal ocean, characterizing its dynamical response and depending on a large extent on the depth distribution as a function of distance from shore. Generally, the coastal constraint holds a longer distance from shore over a flat shelf than over a steep shelf, but a number of other factors enter this question. In any event, the coastal constraint is often found to apply in water of order 100 m in depth.

In such relatively deep water, the force of the wind directly affects only a thin layer at the surface, the rest of the water column responds indirectly, through pressure forces generated by the displacement of water masses. Within the surface shoal layer or subject to direct wind action, turbulence governs the distribution of wind-impacted momentum, while the Coriolis force acts as an important modifier of the flow. A 'lur-

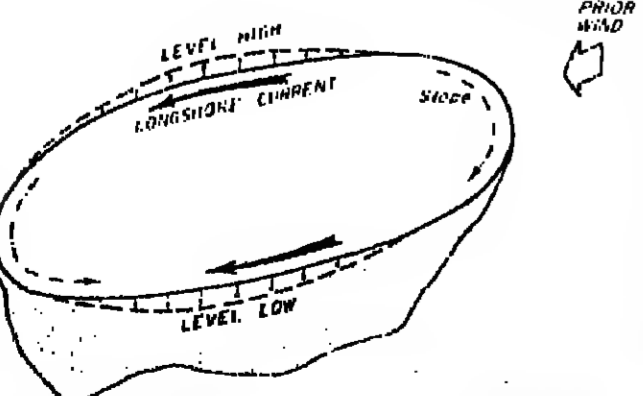


Fig. 3. System of coastal currents generated in a basin of simple shape by uniform wind. Geostrophic balance requires a rise of sea level along one coast parallel to the wind, a fall along the opposite coast.

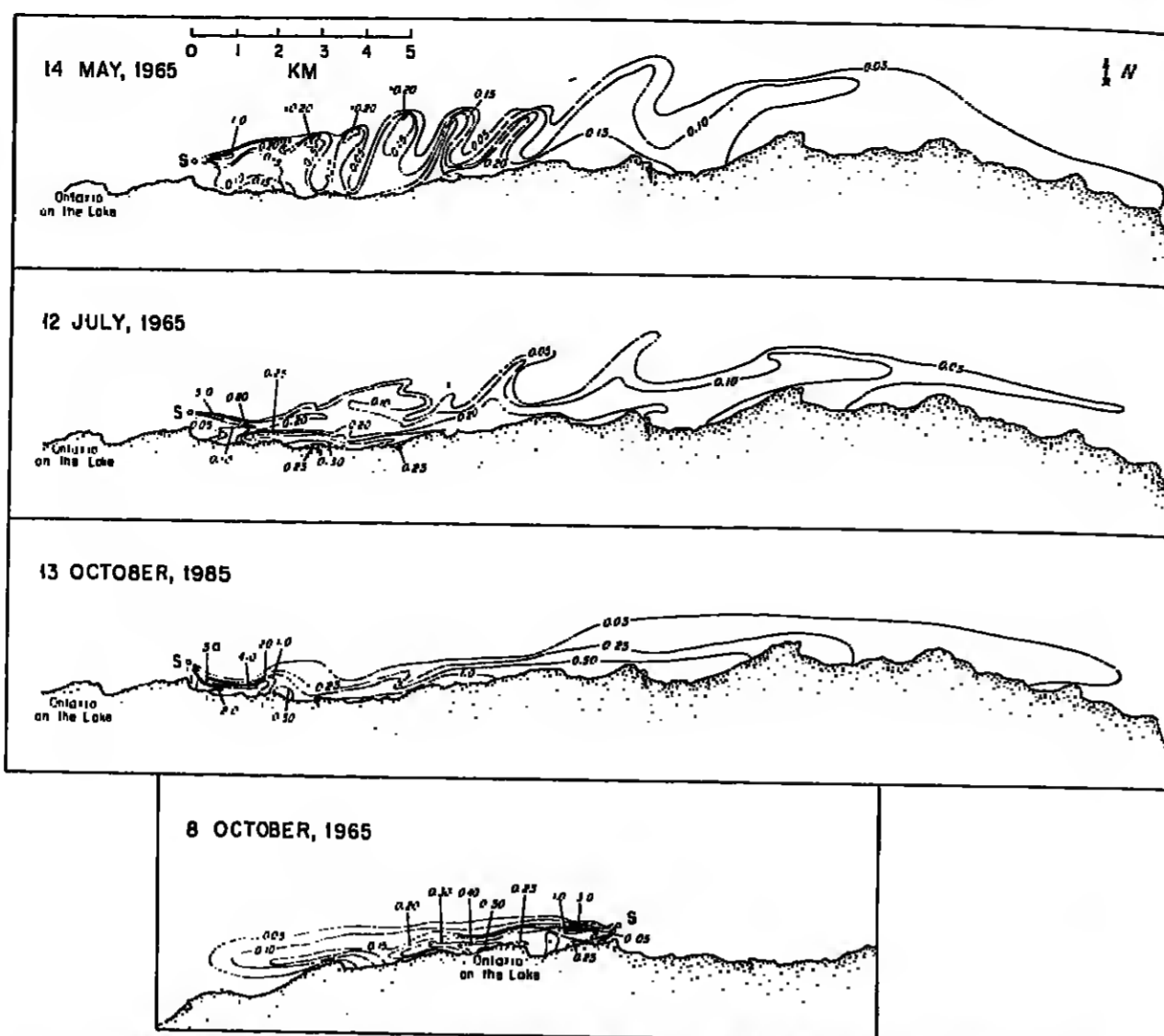


Fig. 4. Outlines of a plume generated by the continuous release of tracer dye from a nearshore source in Lake Ontario. Contours are lines of constant concentration in parts per billion (Pritchard-Carpenter, unpublished report, 1965; available from the authors, 208 Macatino Road, Ellicott City, Md.). When the coastal current reverses direction, previously developed dye plume disappears through efficient mixing with offshore waters.

bulent Ekman layer' develops, the depth of which depends only on wind stress and Coriolis parameter. At mid-latitudes, the typical Ekman layer depths is of the order of 10 m.

Within the Ekman layer, a longshore wind stress causes transport to the right of the wind. To satisfy the coastal constraint, a compensating return transport occurs, evenly distributed over the water column. Where the longshore pressure gradient vanishes, this return flow gives rise to an unbalanced Coriolis force, which accelerates the water alongshore. Similar cross-stream displacements are deduced in other geostrophic adjustment problems, and the phenomenon will be referred to as 'adjustment drift.'

Sea level gradients are generally not negligible in the longshore balance of forces. For example, in a closed basin, wind 'setup' is a well-known effect. When the wind blows along the longer axis of a long and narrow basin, such as Lake Erie or Lake Ontario, the level at the downwind end of the basin rises appreciably. In typical cases in Lake Erie, the level rise is of the order of a meter, a sufficient amount to affect the output of the hydroelectric power plant on the Niagara River.

In a basin of variable depth, 'setup' balances the wind only at the locus of the cross-sectional average depth. Shoreward from the locus, in shallower water, wind stress dominates and accelerates the coastal water mass downwind. In water much shallower than the average depth, the pressure gradient force associated with setup is negligible compared to the wind force, and the previous remarks on flow without longshore gradient apply. In deep water, the pressure gradient dominates and causes return flow.

In a cross-shore transect, given a pressure gradient that opposes the wind stress, interior velocities of the developing quasi-geostrophic flow are similar to those shown in Figure 2. However, the cross-shore motion below the Ekman layer, which compensates for the Ekman drift, is now partly geostrophic flow associated with the longshore pressure gradient. Where the depth is equal to the section average depth, geostrophic cross-shore flow exactly compensates for Ekman drift. In much shallower water, the compensation (in the transient case) is mostly through adjustment drift. Longshore acceleration is only produced by the adjustment drift component.

The above theoretical framework of quasigeostrophic current generation has been empirically confirmed by observations carried out in Lake Ontario during the International Field Year on the Great Lakes (IFYGL, carried out 1972-1973). At 5-10 km from shore, transient currents were found to have peak transports of a magnitude close to that expected from the wind stress impulse. The corresponding coastal-like level rise was documented. Although the cross-shore adjustment drift was not evident in current meter records (which were dominated by stronger signals), they could be inferred from the displacement of constant property surfaces.

Quasigeostrophic longshore currents were also found to be responsible for a rather dramatic difference in current climatology in the Great Lakes between the coastal zone (of order 10-km width) and further offshore. Nearshore, water motions are mostly straight-line and shore-parallel, further away they are dominated by inertial oscillations as already illustrated in Figure 1. Lagrangian tracer studies in the coast-

al zone show long plumes hugging the coast in one direction or another (Figure 4). Tracer released more than 10-km offshore moves in a much more erratic manner, i.e., in essentially all directions of the wind rose.

Lagrangian tracer studies also show the more or less complete disappearance of a tracer plume on the reversal of the coastal current caused by an opposing wind impulse. The adjustment drift is thus seen to perform the very important practical task of renewing the coastal water mass. For a strong enough wind impulse, the renewal is more or less complete.

Similar quasigeostrophic transient currents have also been well documented over continental shelves of the Pacific type. The continental shelf off Oregon has been the subject of intensive observational studies now for almost two decades. Much of this work has been oriented toward the understanding of the seasonal upwelling cycle and its biological implications, but a considerable amount of evidence was also accumulated on the dynamics of wind-driven transient currents. Longshore wind impulses were found to be associated with longshore current fluctuations that were distributed more or less evenly over the water column (below the surface layer). The coastal sea level rose and fell in step with such fluctuations. The presence of an adjustment drift could be inferred from the movement of the constant property surfaces.

Upwelling, Downwelling, and Coastal Jets

The distribution of water properties, salinity, temperature, nitrate and phosphate concentration, etc., is particularly sensitive to the circulation in a cross-shore transect because the streamlines of such circulation often cross sharp gradients. The gradients arise on account of the stratification of the water column that characterizes the coastal ocean in the summer season. A warm (and fresh, over continental shelves) layer of some 20-30 m overlies colder and denser water, and the region separating the two layers (the seasonal pycnocline) is relatively thin, so that it may often be thought of as an interface between two fluids of slightly different density.

In a stratified water column in static equilibrium, surfaces of constant temperature and salinity are horizontal. Cross-shore particle displacements associated with transient winds distort these surfaces in a characteristic way, depending on whether the cross-shore circulation is 'upwelling' or 'downwelling.' These terms refer to the upward motion of bottom water or the downward motion of surface water, respectively.

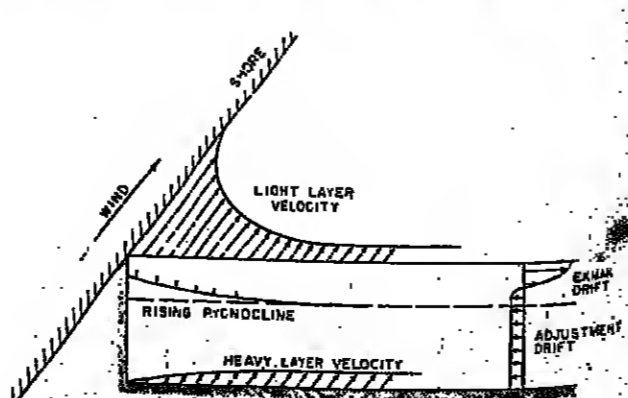


Fig. 6. Characteristics of rising coastal jet. Motion of pycnocline is only significant in a narrow coastal band (typically 5-10 km wide).

Upwelling may cause those surfaces of constant temperature and salinity, which in static equilibrium form a pycnocline or relatively sharp density interface, to intersect the free surface. Conversely, downwelling may lead to the same surfaces intersecting the bottom at a depth several times their equilibrium depth.

As surfaces of constant density depart from their horizontal equilibrium position, horizontal pressure gradients arise in the fluid and affect the adjustment process to geostrophic balance and any resulting steady state of motion. A simple and realistic theoretical model consists of two layers of constant density separated by a frictionless interface. Cherny [1955] analyzed this model and resulted in a quasi-geostrophic solution for an infinite straight coast, constant depth, and suddenly imposed longshore wind on the assumption that the vertical excursion of the pycnocline is small ('linearized' theory). The principal difference between this and the homogeneous fluid case is that within a nearshore band only the top layer fluid responds to the wind by longshore acceleration, the bottom layer remaining quiescent. Consequently, higher longshore velocities arise in the top layer. At the same time the interface begins to rise or sink (depending on the direction of the wind) in such a way as to compensate for the surface level rise and to hold bottom pressure (nearly) constant. The strong surface layer current is then in geostrophic equilibrium with the horizontal pressure gradient associated with the inclination of the density interface and is legitimately called a coastal jet (in analogy with the atmospheric jet stream, which has a similar dynamical structure). The characteristics of a rising coastal jet are illustrated here in Figure 5.

As the coastal jet develops, the interface rises or sinks in a nearshore band of a width comparable to the 'internal radius of deformation,' which in typical coastal oceanic cases is 5-10 km. Far outside this band, the bottom layer moves bodily shoreward or seaward, while the top layer has to accommodate the Ekman drift in the opposite direction. Consideration of interior velocities then reveals a pattern exactly as if there were no density gradients, which was illustrated for a sloping beach model in Figure 2. Very close to the coast, however, there is little motion in the bottom layer. In the top layer, in the usual case when top-layer depth is about equal to Ekman-

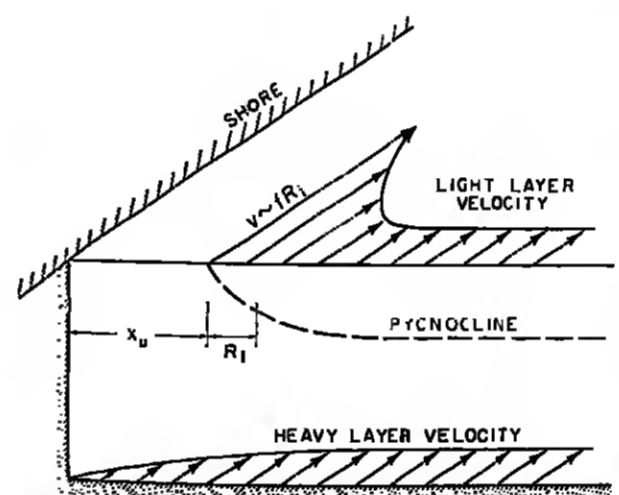


Fig. 5. Fully upwelled pycnocline following a strong enough wind impulse. Light fluid has moved bodily offshore, and the boundary between light and heavy fluid forms a surface front some distance from the coast. The coastal jet moves out from the coast with the pycnocline.

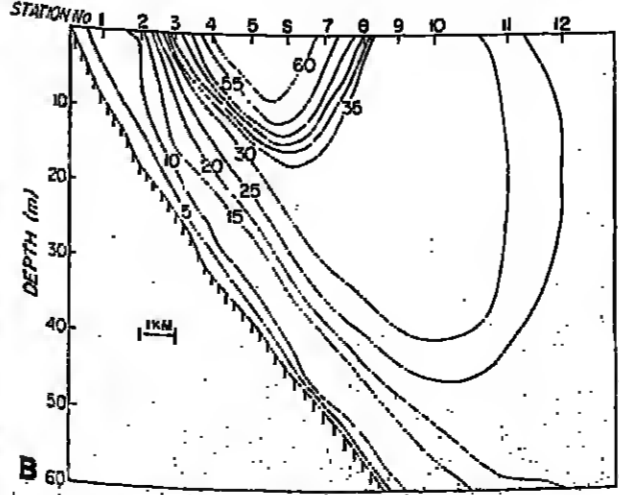
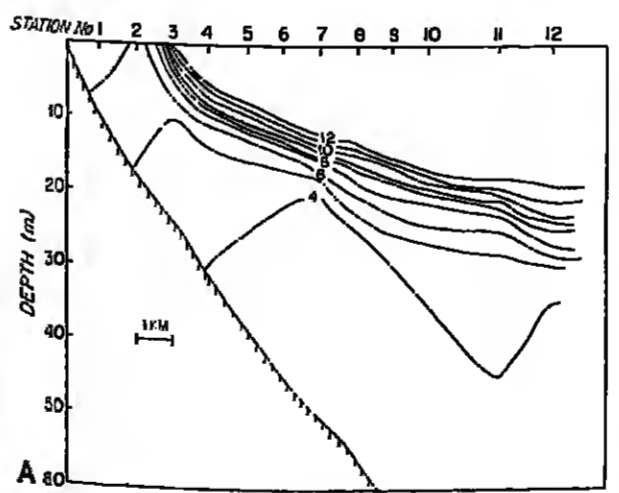


Fig. 7. (a) Distribution of isotherms ($^{\circ}\text{C}$) in cross section of coastal region of Lake Ontario, observed during IFYGL, following strong wind impulse. Surface front is seen about 3 km from shore. (b) Distribution of longshore velocity (cm s^{-1}) observed on the same occasion. Core of the coastal jet lies between 4 and 7 km from shore. (From Csanady [1977].)

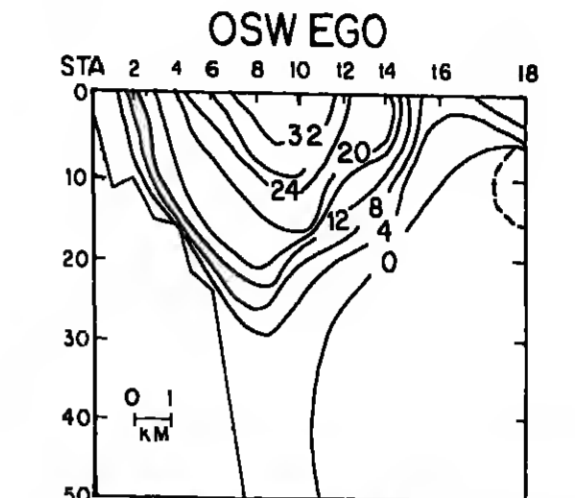
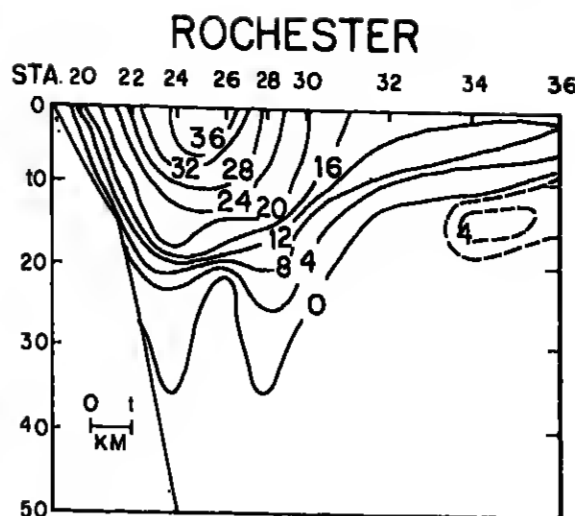


Fig. 8. Distribution of longshore velocity (cm s^{-1} , left) and temperature ($^{\circ}\text{C}$, right) of two cross sections of the coastal region of Lake Ontario, also from IFYGL. The difference between this case and the previously illustrated one is that the velocities are here directed so as to have the coast to the right (i.e., point out of the picture), whereas in Figure 7 they point the other way, into the picture. Geostrophic balance of the coastal jet requires upwelling in the previous case, downwelling in this case. (Adapted from Csanady and Scott [1974].)

layer depth, cross-shore motions are negligible, and the force of the wind is evenly distributed over the top layer and causes uniform longshore acceleration. Where the top-layer depth is considerably greater than the Ekman-layer depth, adjustment drift occurs below the Ekman layer, but in the top layer only.

The most impressive results of upwelling and downwelling are the surfacing of isopycnals some distance from shore, or their sinking to a depth several times their equilibrium depth. The simple classical model, which postulates small vertical pycnocline excursions, does not apply to such cases. A strong longshore wind impulse is usually the cause of 'full' upwelling or downwelling events, with the large pycnocline displacements developing quite rapidly, often within hours or at most a day. It is reasonable to idealize these events by supposing that the wind impulse is evenly distributed over the top layer by vigorous turbulence. One may ask then how the two-layer fluid adjusts to geostrophic equilibrium following such an impulse, with interface and bottom friction neglected and the density of each layer asperely conserved.

The extension of the classical theory on the basis of this idealization is relatively straightforward; it makes use of the principle of potential vorticity conservation (Csanady, 1977). Quantitatively, the principal new result is that the velocity of the coastal jet is limited to a value about equal to the 'density metric velocity' in the same way as maximum velocities are in certain 'critical flow' problems in hydraulics. The longshore momentum balance is completed by the Coriolis force associated with the bodily displacement (adjustment drift) of the entire top layer from shore to a distance of the order of a few kilometers (Figure 6).

It should be pointed out here that an offshore wind also causes upwelling and, if strong enough, may bring the interface to the surface. However, the flow pattern so generated is not in equilibrium without the wind acting, and the interface relaxes to a horizontal position on the cessation of the wind. Thus, in theory, the upwelling caused by a longshore wind is long-lived, an upwelling that is due to an offshore wind ephemeral. In practice, of course, dissipative processes cause the inclined interface that is in geostrophic equilibrium with a coastal jet to relax toward static equilibrium, but this is usually a slow process, with a typical time scale of 5 days or so.

Intense upwelling events are known to occur in a number of coastal locations, notably in the Great Lakes and along the Oregon coast. Early reports described the hydrography of upwelling, while later systematic studies, in the course of large-scale cooperative experiments, provided detailed information also on longshore and cross-shore currents (Smith et al., 1971; Smith, 1974; Moores et al., 1978). In the course of these investigations, some clear-cut upwelling events have been documented. They were produced by a local along-shore wind impulse, and the observed properties of these events compared well with the above simple conceptual picture.

During the International Field Year on Lake Ontario, upwelling events in Lake Ontario could be observed with considerable spatial resolution. Figure 7 shows a well-documented event that occurred in October 1972. The wind stress impulse on this occasion was large enough to produce offshore displacement of a fully upwelled thermocline of some 3 km. The structure and intensity of the coastal jet, as well as the isotherm (= constant density surface) distribution, was very much as expected from the simple theoretical model described above.

Examples of downwelling and associated coastal jets have also been documented in the Great Lakes. An example is shown in Figure 8. This also conforms in all essential aspects to the finite displacement quasigeostrophic model.

Acknowledgments

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Gábor T. Csanady has been a senior scientist with the Woods Hole Oceanographic Institution, Woods Hole, Mass., since 1973. He was educated as a mechanical engineer (Dipl. Ing., Munich) and worked 6 years in the electric power generation industry in Germany and Australia before embarking on graduate work on air pollution meteorology. He received his Ph.D. from the University of New South Wales in 1958. He joined the University of Waterloo, Ontario, in 1960, where he was professor of mechanical engineering and department chairman for a period, while also beginning a series of experimental and theoretical studies on the dynamics of coastal currents in the Great Lakes. In the late sixties these studies were carried out in cooperation with the Great Lakes Institute, University of Toronto, and were stimulated by extended visits to the Department of Meteorology, University of Wisconsin, Madison. Increasing involvement with coastal oceanography led to the move to Woods Hole, where he worked mostly on dynamical problems of continental shelf circulation, with special emphasis on the coastal boundary layer. He was editor of the *Green JGR* for a 4-year term, ending in December 1979, and currently edits a book series on environmental fluid mechanics (Field Publishing Co.). He is a recipient of the President's Prize, Canadian Meteorological Society (1970), the Editors Award, American Meteorological Society (1975), and the Chandler-Misner Award of the International Association for Great Lakes Research (1977). He is author of the monograph 'Turbulent Diffusion in the Environment' (1973) and is currently working on another monograph entitled 'Circulation in the Coastal Ocean.'

News

The Love Canal: Beyond Science?

When in 1978, the New York State Department of Health issued the report, 'Love Canal—Public Health Time Bomb,' the serious effects of chemical waste contamination in the Love Canal area became an issue of national concern. A few 'studies' since then have produced results in concern with those of initial reports that described 'conditions of acute health effects' as being linked to hazardous wastes incorporated in landfills in the Love Canal site near Niagara Falls, New York. Now that a 'blue ribbon' panel of experts from the medical sciences has reviewed the problems of Love Canal, however, a different view has emerged. The 'Report of the Governor's Panel to Review Scientific Studies and the Development of Public Policy on Problems Resulting from Hazardous Wastes,' transmitted in October of this year, identifies the following factors about the health effects at Love Canal:

- Inadequate research designs for health effects studies, particularly regarding chromosome damage and informal surveys of the Love Canal residents;
- The inevitable necessity of time required for longitudinal prospective studies and complex retrospective studies that concern long-term exposure to hazardous wastes.
- Inadequate intergovernmental coordination and cooperation in the design and implementation of health effects studies.

It is apparent that in the 2 years following release of the original New York Department of Health report, a most difficult state of affairs developed. On one hand, there is clear evidence that contamination of the subsurface, groundwater, and household basement areas of the Love Canal residents occurred (toxic chemicals, including chlorinated hydrocarbons and dioxin, among many others). On the other hand, there were no 'short-term' health problems, according to most studies. The result was a state of understandable hysteria of the residents of Love Canal because of the danger of 'long-term' health problems such as the development of cancer, birth defects, and other conditions that might be produced by chromosomal damage. The real problem is that, according to the recent finding of the governor of New York's panel, the science is not well enough developed to understand, much less to prove, a causal relationship.

The alarm raised in 1978 was, in part, a legal requirement of state law section 1388 to 'insure adequate jurisdiction and resources for governmental response to the Love Canal situation.' To obtain support for a 'national disaster,' the New York State Department of Health had to define the disaster. Unfortunately, the state of fear and anxiety that resulted led to an unfortunate test of the scientific method. The panel report states:

This Panel recognizes that there was a reason for the State Health Department's initial announcement of 'Public Health Time Bomb,' but not a good enough reason. There ought to be a better mechanism for convincing the Federal government that a certifiable disaster area exists, in order to obtain Federal funds, than to arouse such fears of imminent peril as swept through the Love Canal area in this case. A better mechanism might have been found if effective Federal/State consultations had been launched promptly when the problem was first recognized. It may be that the atmosphere of public hysteria which was created in mid-1978 contributed to the failure on the part of public health agencies to put together an appropriately orderly, deliberative and systematic investigation of the situation.

This Panel acknowledges that the Love Canal problem was something quite new, a situation not encountered before by public health agencies. In the past, instances of environmental pollution emerged as sudden, acute episodes, usually derived from a single industrial source, with readily discernible and quantifiable health hazards. Love Canal, in contrast, represented the chronic contamination of a whole community's living space, extending back over a period of decades, and most complex of all, involving not one but scores of different chemicals seeping through the earth and into households all at once. No book of rules exists for handling this kind of problem, but from now on it is obvious that rules will have to be formulated.

The Environmental Protection Agency (EPA) released a study of the problem that the panel describes as 'a paradigm of administrative ineptitude.' Although the EPA qualified its findings to be used with 'prudence' because of inadequacies of the study, the findings were widely distributed, nonetheless. According to the panel report:

The public was given the strong impression that the Love Canal problem was endangering the survival of all contacts and their offspring. During the next few weeks the Biogenics report (based on the EPA findings) was reviewed by several groups of experts in the field of cytogenetics, with expressions of doubt that the reported results were of significance. These were particularly critical of the techniques employed, the lack of controls, and the possibly artifactual nature of the supernumerary acrocentric fragments.

With so much at stake for the residents involved, to have set up experiments that lead to public conclusions of such magnitude, without prior review of the protocol by qualified uninvolved peer scientists, and without any other fact, independent review of competent scientists before release of the results, was a disservice to the citizens most intimately concerned and, as well, to the public at large.

It is a pity that this matter was so badly handled. There was no good reason why the responsible authorities in EPA could not have consulted beforehand with their counterparts in the New York State DOH, and enlisted the advice and close participation of outside consultants

with international reputations in the field of cytogenetics, and then mapped out a thorough, careful and scientifically valid approach to the question of chromosome injury.

There is now no question that a proper cytogenetic study is urgently needed. The Panel does not know whether the degree of chromosomal injury claimed in the Biogenics Laboratory study, even if confirmed, is in itself a reason for alarmed predictions concerning cancer or congenital defects—indeed, similar chromosomal abnormalities are characteristically observed in other circumstances (measles, for example) without known sequelae. However, the mere fact that the chromosomal damage is real—if it is—means that the residents of Love Canal are being biologically affected by something in their environment, and this observation—il confirmed—would greatly weaken the position, taken by some, that the only ill effects suffered by this population are psychological.

There will be, no doubt, countless studies of the Love Canal incident in the future. The U.S. Public Health Service, the National Academy of Sciences, and the New York State Department of Health will initiate studies or maintain progress in studies now underway. Perhaps science will benefit by these studies, and, possibly the forefront of environmental health research will be extended. Right now the important questions about cause and effect, risk assessment, and acceptable levels remain unanswered. —PMB

Postal Cancellation From Spaceport

The John F. Kennedy Space Center, in cooperation with the United States Postal Service, is offering a cancellation service to interested philatelists for the space flight program at Kennedy.

Philatelists who wish to avail themselves of this service may do so by following the procedures outlined below:

- Specify the event for which you wish this service. There is a limit of five covers per customer per event.
- All covers must be self-addressed and bear at least first-class postage or proper postage for international mail, placed three quarters of an inch down from the right top of the cover. Envelopes should contain a filler not to exceed the thickness of a postal or computer card to assure a clear cancellation.
- All inquiries must be accompanied by a stamped, self-addressed envelope.

Requests for service must be received at least 5 days prior to an event, but no earlier than 30 days before. Requests should be sent to Chief, Mail and Distribution Services, SI-SRV-1M, Kennedy Space Center, FL 32899. Services not provided are:

- requests for personally autographed covers, or for carrying covers on board during flight or preflight activities;
- cachet service (rubber stamp) for such major events as the first launch of the space shuttle;
- hand-back service.

Since the Kennedy Space Center post office is open only Monday through Friday, excluding federal holidays, envelopes cannot be cancelled on Saturday or Sunday. Cancellations for minor events cannot be given because access to these schedules is not available. ☐

Radio Astronomy in Earth Studies

A high precision radio astronomy system has been adopted and used at the Goddard Space Flight Center in studies of the movement of the earth's crust. Very Long Baseline Interferometry (VLBI) can measure the rotation of the earth, and polar motion, with a current precision of better than 10 cm. Such precise measurements may shed light on the relationship between changes in the earth's orientation and movements in the earth that are associated with large earthquakes. Such movements may occur before an earthquake, but so slowly and over so large a region as to be undetectable by conventional means. Using VLBI stations, the Crustal Dynamics Project has made measurements on the longer baselines to measure continental drift, and on the shorter ones to monitor regional activity.

The technique uses two or more antennas to observe fixed extragalactic sources, usually quasars. Applying this principle to Earth crustal studies, the quasar signal's difference in arrival times at the two stations can be used to geometrically determine the distance between the two stations with a high degree of accuracy.

The baseline, or straight-line distance, between stations at Westford, Massachusetts, and Bishop, California, has been measured with a precision of 3 cm, or better than one part in a hundred million.

Formation, with other countries, of a global station network and some of its work were reported by geophysicist Chopo Ma at the AGU Fall Meeting in San Francisco, December 10. Ma reported that a number of fundamental questions in geophysics are now being investigated by using space techniques. What is the nature and magnitude of tectonic plate motion? What is the behavior within a plate, especially continental plates such as North America? What is the relationship between fluctuations in the earth's rotation and large earthquakes?

The VLBI method is now using a highly sensitive, accurately calibrated, automated system (Mark III) which is designed for making geodetic measurements with fixed or mobile radio astronomy antennas of various sizes, ranging from 4 to 84 m in diameter. The project has conducted geodetic observations with the Mark III systems at fixed radio astronomy stations in California and Massachusetts, mentioned earlier, and at Green Bank, West Virginia; Ft. Davis, Texas; Onsala,

Sweden; Bonn, W. Germany; and Chilbolton, England. The Crustal Dynamics Project group at the Jet Propulsion Laboratory is implementing the Mark III system into a mobile station for measurements of crustal movements in the western United States.

Since 1976, measurements from Massachusetts to West Virginia and California indicate overall continental stability, i.e., no more change than 2 cm/year. The baseline to Texas, first measured in April 1980, will allow more detailed examination of the eastern and western sections of North America. Many measurements have been made in California since that is an area of known regional activity.

In cooperation with the National Geodetic Survey and several international organizations, VLBI measurements were made by NASA in July, September, and October 1980, as part of the Monitoring Earth Rotation and Intercomparison of Techniques Program. These data, equal in amount to what was acquired in two previous years, are now being analyzed and are to be published next spring. They will provide unprecedented opportunities to compare the details of the earth's orientation as determined by other techniques and to check the United States-to-Europe baseline for plate motion and stability. —PMB

New Marine Studies Center

Temple University has established a Center for Marine Studies with faculty members from four of its colleges. The center will offer courses leading to a certificate in marine studies.

Studies will focus on urbanization's impact on the marine environment and will focus on management and economics of waterfront utilization. In addition, faculty members will be constructing an artificial reef off Absecon Inlet to determine if increasing protective environments will permit increased sport fishing.

Courses offerings will range from oceanography and marine biology to scuba diving and underwater research and data collection.

For additional information about the center, contact Robert Leahy, Director, Center for Marine Studies, Temple University, 209 Beury Hall, Philadelphia, Pennsylvania 19122 (call 215-787-8720). ☐

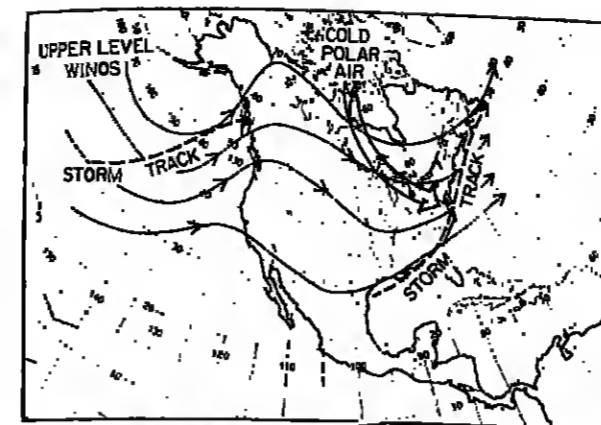
Weather Predictions on Target

The western third of the United States will be warmer and drier than normal this winter, according to Jerome Namias, a meteorologist at the Scripps Institution of Oceanography's Climate Research Group. However, the east coast will be colder and wetter than normal, he predicted. These predictions, made early in December, have proven correct through the beginning of January.

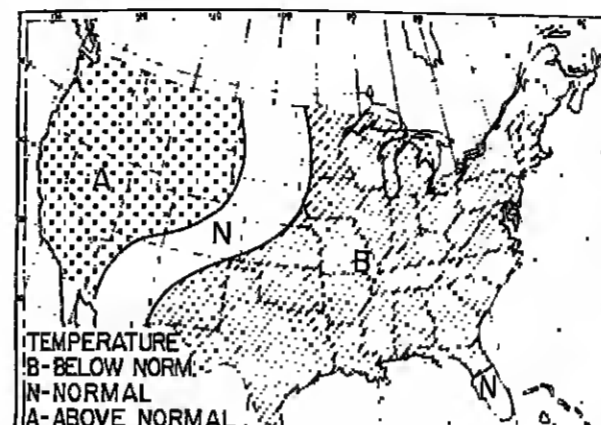
Indications point to colder than normal temperatures over the eastern half of the nation and also over the Southwest from New Mexico through Oklahoma and Texas, and warmer than normal temperatures over the western third of the nation, said Namias, a principal investigator for Scripps' North Pacific Experiment (Norpac). Florida will probably experience near-normal temperatures.

A major change from last winter's weather, the predicted pattern is the result of a trough in the prevailing winds between 3,000 and 12,200 m. Last winter's weather was mild from the Great Plains eastward to New England, dry and relatively snowless over much of the East, but abnormally wet over the Southwest, particularly in California.

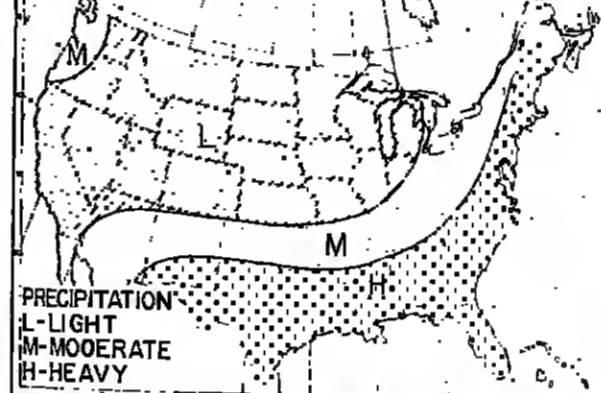
This winter, the prevailing wind trough is expected to extend from New England southwestward to Texas, where a strong ridge is expected over the Canadian Rockies and



Predicted for winter (December 1980, January and February 1981). Source: Scripps Institution of Oceanography.



Predicted for winter (December 1980, January and February 1981). Source: Scripps Institution of Oceanography.



Predicted for winter (December 1980, January and February 1981). Source: Scripps Institution of Oceanography.

along the West coast. This wind pattern would encourage movement of cold polar air masses into the East but would shield the West, Namias explained. This pattern also favors more frequent storms along the Gulf Coast and the Atlantic seaboard.

In the East, some of the snow, once generated, would influence the atmosphere that would further refrigerate the air, he said. 'By increasing the temperature contrast between the continent and the Gulf Stream, development of East coast storms would be enhanced,' Namias adds.

The Dakotas, Nebraska, and parts of Colorado, New Mexico, and Arizona, which lie in a region between the above and near-normal temperature zones, will experience large weekly temperature fluctuations that will average out to near-normal temperatures for the season.

Namias' weather-prediction techniques utilized, in part, data on ocean-wave temperatures as indicators for changes in climate over the continents. ☐

Federal Coal Directory

A new catalog that provides the addresses and the telephone numbers of more than 400 national and local coal-related offices of the U.S. Geological Survey, Office of Surface Mining, and the Bureau of Land Management is available from the USGS.

The 41-page publication, a cooperative effort of the three departments of the Interior agencies, contains a statement of each of the bureau's functions and activities and a listing by state of selected headquarters offices and field offices.

Single copies of the new publication, 'Catalog of Selected Offices of the Office of Surface Mining, Bureau of Land Management, and the Geological Survey Relating to Coal, 1981' (USGS Circular 840), may be obtained free of charge from the USGS Branch of Distribution, 804 South Pickett Street, Arlington, Virginia 22204. ☐

Atmospheric Sciences Assistantships

Research assistantships for graduate students in the atmospheric sciences are available from the National Center for Atmospheric Research (NCAR). Research topics should cover atmospheric dynamics, climatology, cloud physics, atmospheric chemistry and radiation, upper atmosphere physics, solar and space physics, oceanography, or environmental and societal impact assessment.

Appointments are full-time and offer salaries of \$8085 for students who have passed comprehensive examinations and \$7620 for those who have not. Maximum tenure for Ph.D. candidates is usually two years, but M.S. candidates are usually restricted to 1 year. In unusual cases, an additional year may be possible.

Additional information may be obtained from Betty Wilson, Administrator, Advanced Study Program, NCAR, P.O. Box 3000, Boulder, Colorado 80507. ☐

Geophysicists

Nell H. Berg is now in charge of snowpack research for the Forest Service's Pacific Southwest Forest and Range Experiment Station in Berkeley, California. In his new position, he will direct a team of scientists to study forest management in the snow zones of the Sierra Nevada and Coast Ranges in California.



Paulikas

George A. Paulikas has earned a Truefitt's Distinguished Achievement Award for 'outstanding international leadership in magnetosphere physics and its applications to military space systems' at The Aerospace Corporation. The award consists of a bronze plaque and \$10,000 cash.

Paulikas, associate editor of the *Journal of Geophysical Research*, 1972-1974, has been director of Aerospace's Space Sciences Laboratory since 1988.



Spilhaus

Athelstan Spilhaus will be a Distinguished Scholar at the Center for the American Experience, Annenberg School of Communications, and a research fellow in the Institute for Marine and Coastal Studies, University of Southern California, Los Angeles, from January through June 1981.

Herbert W. Sloughton joined the geodetic survey squadron of the Defense Mapping Agency at the F. E. Warren Air Force Base in Wyoming.

Robert L. Wesson has been officially appointed assistant director for research at the U.S. Geological Survey in Reston, Virginia. He succeeds James R. Bales, who retired a year ago. Wesson has contributed to earthquake research aimed at prediction and mitigation of quake hazards.

Geophysical Events

This item comprises a selected portion of *SEAN Bulletin*, 5 (11), November 30, 1980, a publication of the Smithsonian Institution.

Volcanic Activity

Mount St. Helens Volcano, Cascade Range, southern Washington, U.S.A. (48.2°N, 122.18°W). All times are local (GMT - 8 h). After the explosions of October 18-19 and the brief period of lava dome growth that followed, activity at Mount St. Helens was limited to vapor emission and occasional seismic activity through early December.

Most early November seismic events were caused by rock slides from the crater walls. No significant local earthquakes or harmonic tremor were recorded until mid-November, when brief episodes of harmonic tremor began, barely within the detection limits of sensitive seismographs on and near the volcano. Intermittent low-level tremor continued through early December. Stronger tremor started on November 26 at 2054, gradually fading into background noise about 35 minutes later. Observers in a U.S. Forest Service aircraft reported a slightly brighter glow in the dome area after this event. A second burst of stronger tremor began November 27 at 2034, continuing for about an hour, and several more such episodes, lasting only a few minutes each, were detected through November 30.

U.S. Geological Survey monitoring of the north crater rampart revealed a maximum net outward movement of about 23 cm between the October explosion and November 28. However, a major reversal to inward movement occurred in late October before an outward trend resumed in November. Outward growth accelerated in mid-November to slightly more than 1.5 cm/day at times, a rate similar to that recorded during the summer.

TABLE 1. Averages for Each Eruptive Episode of Mount St. Helens, May 18 to August 7

Number	SiO ₂	Al ₂ O ₃	FeO*	MgO	CaO	K ₂ O	Na ₂ O	TiO ₂	P ₂ O ₅	MnO	Sum
1	84.13	17.81	4.04	1.88	4.80	1.25	4.83	0.58	0.15	0.00	99.18
2	84.19	17.92	3.99	1.91	5.08	1.29	4.83	0.60	0.16	0.00	99.94
3	83.72	18.04	4.24	1.99	5.18	1.25	4.70	0.64	0.16	0.00	99.89
4	83.49	17.87	4.44	2.20	5.22	1.28	4.87	0.57	0.18	0.00	100.17
5	83.28	17.51	4.38	2.17	5.30	1.23	4.89	0.64	0.18	0.00	99.57

*Electron microprobe analyses of fused powders by W. Mielson, T. O'Hearn, and J. Nelson, Smithsonian Institution. Samples collected by D. Swanson, C. Hopson, W. Malone, R. Fluke, and C. Kiehle. 1, May 18 average nine analyses; 2, May 25 average 11 analyses; 3, June 12 average nine analyses; 4, July 22 average nine analyses; 5, August 7 average 10 analyses. *Total iron calculated as FeO.

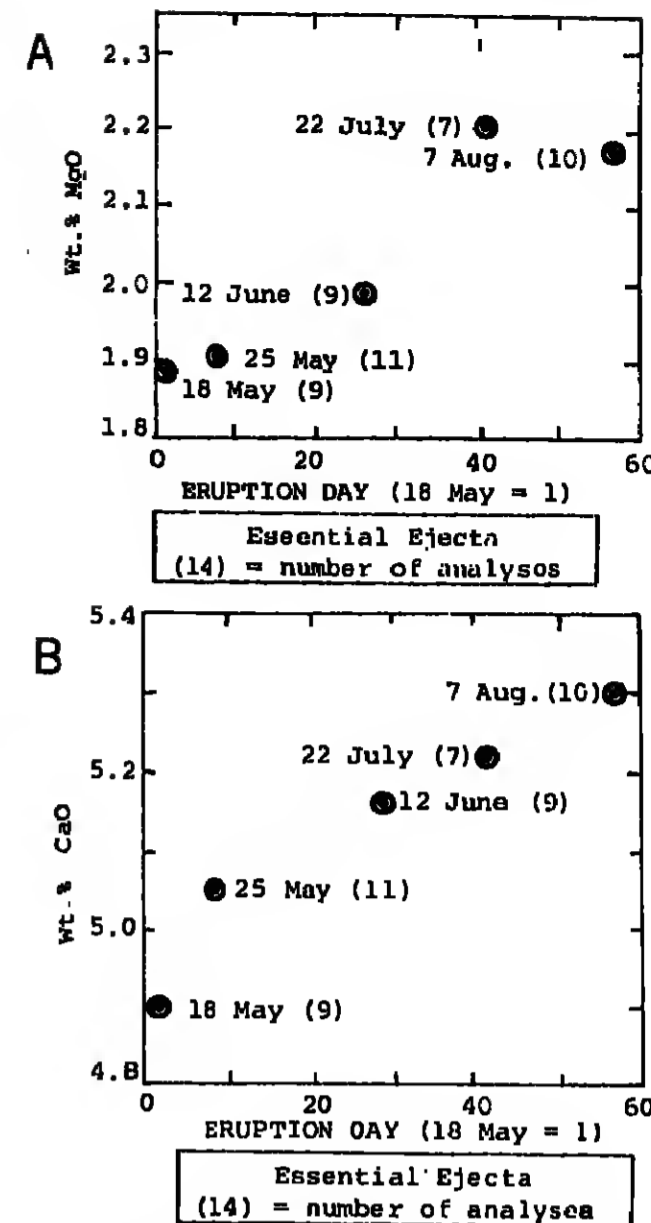


Fig. 1. (a) Average MgO and (b) CaO concentration in eruptive rocks from each eruptive episode at Mount St. Helens, May 18 to August 7, plotted against time of each episode (May 18 = 1). Analyses are of fused powders by the electron microprobe. Numbers in parentheses are the number of samples analyzed and included for average value.

ing the summer. About 20 cm of expansion was measured between November 12 and 26.

No major changes have taken place in the volume or ratio of gases emitted by the mountain. Two large fumaroles opened in the crater floor, very close to the margin of the lava dome, one on November 18 or 19, the other on November 25. As they opened, both ejected mud (containing no fresh magma) that coated snow on the flank. As of early December, the new fumaroles were 2-3 m across, glowed cherry red, and puffed noisily at half-second intervals.

The following is a report from W. G. Mielson.

A small but definite trend toward andesite compositions is revealed by major element analyses of the 18 May to 7 August eruptives. A total of 48 samples of probable essential ejecta have been analyzed (Table 1 and Figure 1a and 1b) a minimum of five such samples from each eruptive episode. The trend is an irregular one and is more pronounced with regard to MgO and CaO when plotted against time of eruption.

Information contacts: Tom Casadevall, Chris Newhall, and Don Swanson, U.S. Geological Survey Field Office, 301 E. McLaughlin, Vancouver, WA 98663.

Robert Tilling, U.S. Geological Survey, Stop 906, National Center, Reston, VA 22092.

Steven Melson, Robert Crosson, and Elliot Endo, Graduate Program in Geophysics, University of Washington, Seattle, WA 98195.

William G. Mielson, NHB Stop 119, Smithsonian Institution, Washington, D. C. 20560.

Pavlov Volcano, Alaska Peninsula, Alaska, U.S.A. (55.42°N, 151.90°W). All times are local (GMT - 10 h). An eruption from Pavlov November 11-12 ejected large lava fountains and ash clouds that reached 11 km altitude and may have produced lava flows.

A seismic station 10 km southwest of Pavlov registered a 2 1/2 min burst of low-amplitude harmonic tremor beginning on November 5 at 1351. Emission of steam, ash, and some blocks from a vent high on the northeast flank started November 8 at 1047 and lasted about 5 min, without accompanying seismicity. A second burst of low-amplitude tremor

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occurred between 0536 and 0541 on November 9. In contrast to the pattern observed before eruptions in 1973, 1974, 1975, and 1976, virtually no additional seismic activity was recorded until a group of seven low-frequency volcanic earthquakes occurred at about 2300 on November 10. After an explosion event appeared on seismic records at 0243 on November 11, 10 more low-frequency volcanic earthquakes were recorded between 0300 and 0400. Continuous harmonic tremor, of fairly low amplitude, began at 0608, but amplitude intensified around 0900.

Reeve Alutian Airways pilot Everett Skinner saw rocks up to 1 m in diameter rising 10 to 30 m at 1315 on November 11. An observer in Cold Bay, 80 km to the west, noted an increase in activity about 1600. Skinner returned to the vicinity of Pavlov between 1630 and 1700, reporting lava fountains from the summit, a black cloud hugging the volcano's upper north flank, and an eruption column reaching an estimated 6 km altitude. Between 1800 and 2000, various witnesses reported lava fountains to a maximum height of 300 m and incandescent material moving down the north flank. A satellite image returned at 1958 shows a nearly circular plume, 15 km in diameter, north of the volcano. Activity was visible through the night from Cold Bay (see above) and the Sand Point area (50–65 km to the east northeast).

The next morning, at 0948, a satellite image revealed a plume 160 km long and almost as wide spreading north of Pavlov. Spectral analysis and weather balloon data indicate that the plume reached 8–9 km above sea level. Pilot reports on November 12 placed the top of the eruption cloud at 9 km at 1000, 6 km at 1100, and 11 km at 1400. The eruption clouds were described as varying from ash-rich to ash-poor. A helicopter crew from KENI television, Anchorage, videotaped pulses and bursts of lava fountaining, rising 150–300 m between 1600 and 1700. The fountain emerged from a preexisting vent high on the northmost flank, the only vent confirmed active during the eruption.

Very high amplitude harmonic tremor accompanied the eruption, reaching its strongest levels between 2000 on November 11 and 0700 on November 12. Tremor ceased at 1835 on November 12, at which time many B-type earthquakes began to be recorded.

By the morning of November 13, the eruption had ended. Several hundred B-type events per day were recorded November 14–15. Renowned high-amplitude tremor began November 15 at 1306, lasting until 1711. B-type earthquakes continued November 18–19, but lower than 100/day were recorded.

Information contacts: S. McNitt and J. Davies, Lamont-Doherty Geological Observatory, Palisades, NY 10964. Alison Tili, U.S. Geological Survey, 1209 Orca St., Anchorage, AK 99501.

Jürgen Klenke, Geophysical Institute, University of Alaska, Fairbanks, AK 99701.

G. Roberts, Cold Bay Weather Station, Cold Bay, AK 99571.

Commander John Hair, Chief, Marine Environmental Branch, P.O. Box 3-5000 (MEP), Juneau, AK 99802.

Garolai Volcano, Aleutian Islands, Alaska (51.80°N, 178.80°W). All times are local (GMT - 10 h). On August 10 and 11, SO₂ from a fresh volcanic plume was detected from a research aircraft (flown by NASA under contract from the U.S. Department of Energy) at 19.2 km altitude just south of Anchorage, Alaska.

Imagery returned August 8 at 1010 by the NOAA 8 Satellite shows a high-altitude plume appearing to originate from the vicinity of Garolai. Using a drift rate of 30 km/hr, Los Alamos Scientific Laboratory personnel calculated that the eruption which produced this plume had probably ended about 10 h earlier. Later visible and infrared images show the plume moving toward the Anchorage area, about 2000 km from Garolai, at a rate that could have brought it to the sampling area by August 10. The eruption column seen emerging from Garolai August 9 by a commercial pilot was also present on satellite images, but clearly was not large enough and did not reach a high enough altitude to have been the source of the material sampled August 10–11. Wind conditions also preclude the August 7 eruption clouds from Mount St. Helens as a source for SO₂ in the Anchorage area at this time.

Information contacts: W. A. Sedlacek, G. H. Heiken and E. J. Mroz, Los Alamos Scientific Laboratory, Los Alamos, NM 87545.

Kratla Caldera, Myvatn Area, Iceland (65.71°N, 16.75°W). The following is a report from Karl Grönvold.

After the October eruption the magma reservoirs at Kratla initiated rapidly until the last week of November. Ground level monitoring indicates that at that time land height over the magma reservoirs was higher than before the October eruption. During the week or so prior to 3 December, the rate of inflation has been slower and more irregular.

From the pattern of behavior so far, an eruption can be expected to take place soon. Evacuation plans and civil defence measures have been strengthened in case of an eruption in the southern part of the leisure system, closer to the village near Lake Myvatn.

Information contact: Karl Grönvold, Nordic Volcanological Institute, University of Iceland, Reykjavik, Iceland.

Langila Volcano, New Britain Island, Papua New Guinea (5.53°S, 148.42°E). The following is a report from the acting senior volcanologist.

Intensified eruptive activity that began in mid-October continued until 8 November. Dark emission clouds continued to be released from crater 2, and emission clouds from crater 3 were pale grey. Ejection of incandescent lava fragments from both craters were accompanied by rumbling and explosion sounds. The lava flow from crater 3 was reported to be still active on 11 November.

A decline in the intensity of the eruption was evident on 8 November, when seismograph attenuation was reduced by 18 decibels. However, glow and ejections of incandescent lava fragments continued from both craters, and gray ash and vapor clouds continued to be emitted.

Information contact: Acting senior volcanologist, Rabaul Observatory, P.O. Box 386, Rabaul, Papua New Guinea.

Kavachi Volcano, Solomon Islands, Southwest Pacific (9.03°S, 157.93°E). Soleir pilot flying over Kavachi Volcano on October 14 observed a smaller submarine eruption to that reported by Chief Pilot Bruce Kirkwood on October 7, although there appeared to be more mud in the surrounding seas than during the earlier activity. By October 23, activity had decreased to occasional bursts of hot water at the surface.

Information contact: Dani Tunli, Geology Division, Ministry of Natural Resources, Honiara, Solomon Islands.

Volcano Activity in the Philippines, September–November

Bulusan Volcano, Luzon Island (12.77°N, 124.05°E). Bulusan's most recent ash eruption, on September 28, was followed by a series of volcanic earthquakes which became less frequent with time. Felt events of intensity I to II on the Modified Rossi-Forel Scale have also occasionally been recorded.

Mayon Volcano, southeast Luzon Island (13.26°N, 123.62°E). Short-duration harmonic tremor was first noted at Mayon on August 18. Occasional tremor continued through November, and as of November 30, 214 episodes had been recorded. Similar seismicity preceded the 1978 eruption and accompanied crater glow in July 1979.

Canlon Volcano, Negros Island (10.41°N, 123.13°E). Seismic activity at Canlon has lessened considerably since it started on May 6, 1980, but remained above normal as of late November. Canlon last erupted in mid-1978, ejecting ash intermittently.

Information contact: Olimpio Peña, Acting Commissioner, Commission on Volcanology, 5th floor, Hizon Bldg., Quezon Blvd. Ext., Quezon City, Philippines.

Myojinsha Submarine Volcano, Marianna Islands, Japan (31.82°N, 139.92°E). All times are local (GMT + 9 h). The crew of the fishing boat Suisenmaru 11 saw discolored water over Myojinsha on November 15 at around 1530. They reported that no discoloration had been seen there the morning before. Personnel from the Japan Maritime Safety Agency (JMSA) flew over the site on November 16 and observed three circular areas of pale green water, each 50–80 m across, aligned within a 300-m zone. These were also seen the following day by the crew of the fishing boat Shinkomaru 26 and again by JMSA personnel on November 28. No floating ejecta or upwelling of water were noted, however.

The November activity is the first since July 13, 1979, when JMSA observed discolored water. In 1952, 31 persons aboard the research vessel Keiyo Maru 5 were killed by a violent phreatic eruption of Myojinsha.

Information contacts: Japan Maritime Safety Agency, 5-3 Tsukiji, Chuo-ku, Tokyo, Japan. Seismological Division, Japan Meteorological Agency, 1-3-4 Otomachi, Chiyoda-ku, Tokyo 100, Japan.

Submarine Volcanos, Volcano Islands, North Pacific Ocean. The Japan Maritime Safety Agency (JMSA) continues frequent monitoring flights over several known submarine volcanoes (see table below). The most active of these Fukuioku-oka-no-ba (24.28°N, 141.52°E), formed islands in 1904 and 1914, and discolored sea water in 1950, 1952–1953, 1955–1956, 1958–1959, 1962, 1967–1968, and 1973–1980. Discoloration has also been seen occasionally over Fukuiji (21.93°N, 143.47°E) each year since 1977. Minamihiyoshi (23.50°N, 141.90°E) discolored seawater January–March 1977 and January–March 1978, but has not been active since. An adjacent vent, Nkko (23.08°N, 142.32°E) has shown no signs of activity since July 1979. (See Table 2.)

Information contacts: Same as for Myojinsha.

TABLE 2. Volcanic Activity at Three Sites in the Volcano Islands, April to October, 1980

Date of Observation	Fukuioku-oka-no-ba	Minami-hiyoshi	Fukuiji
April 24	D	N	N
May 12	D	N	D
June 18	D	N	N
July 7	D	N	N
July 8	D	N	N
July 14	D	N	N
August 18	N	N	N
September 4	N	N	N
October 21	N	N	N

D, discolored water observed; N, no discolored water. Blank, no overflight.

Sakurazima Volcano, Kyushu, Japan (31.58°N, 130.65°E). The number of explosions recorded at Sakurazima declined from 21 in September to 4 in October, then increased to 21 in November (see Table 3). The highest October ash cloud reached 2.0 km on the first. None of the October activity caused any damage. Lapilli from the largest November tephra cloud, which rose 2.5 km on November 8, broke lava car windshields. The shock from the November 28 explosion broke two windows in a hotel at the base of the volcano. No injuries were reported.

The November 23 explosion was the 287th of 1980, making the year's total the greatest since 1974.

Information contact: Seismological Division, Japan Meteorological Agency, 1-3-4 Otomachi, Chiyoda-ku, Tokyo 100, Japan.

TABLE 3. Explosions From Sakurazima, October–November 1980

	Number of Explosions
October	
1	1
18	1
19	1
24	1
Total	4
November	
1	2
2	1
3	3
7	2
8	2
9	1
10	1
13	2
22	1
23	2
24	3
28	1
Total	21

Asema Volcano, central Honshu, Japan (36.40°N, 138.53°E). Monthly seismicity at Asema increased from 1114 recorded events in September to 1350 in October (see Figure 2), the highest monthly total since August 1977. Seismic activity decreased to 897 recorded events in November. No eruption or increase in steam emission was observed. Asema last erupted in 1973, when the number of earthquakes reached 5812 per month.

Information contacts: Same as for Sakurazima.

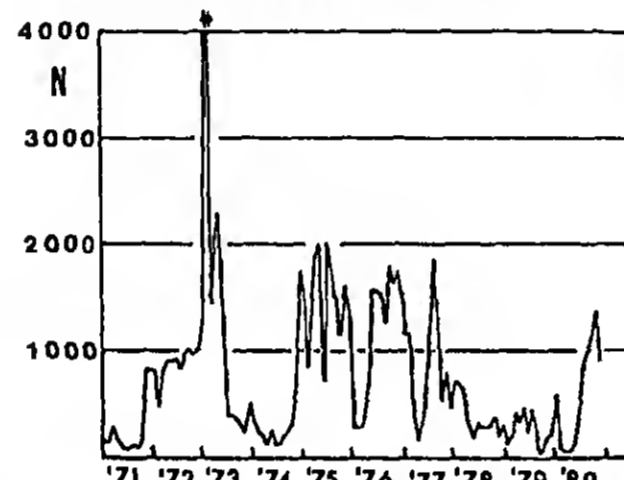


Fig. 2. Number of seismic events recorded per month at Asema, January 1971 to November 1980. The eruptions of February and March 1973 are indicated by arrows at the top of the figure.

Earthquakes

	Time, GMT	Magnitude	Latitude
Nov. 8	1028	7.4 M_s	41.18°N
Nov. 11	1037	6.9 M_s	51.43°S
Nov. 12	0658	5.2 m_b	13.09°S
Nov. 23	1835	6.9 M_s	40.81°N
Nov. 28	1738	4.7 m_b	8.10°N

Longitude	Depth of Focus	Region
124.34°W	14 km	off the coast of north California
28.84°E	10 km	Atlantic-Indian Ridge south of Africa
74.45°W	shallow	south central Peru
15.34°E	8 km	south Italy
72.22°W	shallow	east Venezuela

The California earthquake caused a bridge collapse that injured six persons, but damage was generally light and no other injuries were reported. The Peru shock killed at least seven people, injured at least 20 others, and left thousands homeless. Casualties and damage were concentrated in the San José area, 80 km east of Ayacucho. About 25,000 km² of south Italy were devastated on November 23. As of early December, official casualty figures listed 3105 as killed, 1579 missing, and presumed dead, and 1871 injured. An estimated 200,000 were left homeless. The November 28 event injured 36 people and badly damaged 30 buildings in Cucuta, Colombia, on the Venezuelan border.

Information contacts: National Earthquake Information Service, U.S. Geological Survey, Stop 967, Denver Federal Center, Box 25046, Denver, CO 80225.

Reuters.
United Press International.
The Associated Press.
The New York Times.

Fireballs

Atlantic Ocean, November 15, 2300 GMT. Observer: Capt. Zwegler, F/O Graf, F/E Kogel of Luftwaffe Flight SH 618, (Cerecas - Frankfurt). Location: 22.45°N, 48.16°W, aircraft course 031° magnetic, altitude 8.8 km.

First sighting: 76° magnetic, 30° above horizon. Last sighting: 81° magnetic, 10° above horizon. Duration: 20 s.

Apparent brightness: like full moon.

Color: white at the beginning, yellow at the end.

Size: about half of the full moon.

The object initially possessed a smoky tail about 4 times the length of its head. When last seen, the fireball was separating into four or five pieces. A yellow afterglow lingered for 5–7 s.

Information contact: Gerhard Pointitzky, Universitäts-Sternwarte, Tierkenschanzstrasse 117, A-1180 Wien, Austria.

Atlantic Ocean, November 17, 0108 GMT.

Observers: Capt. Helle, F/O Behrendt, F/E Schmidt of Luftwaffe Flight LH 421, (Boston - Frankfurt). Location: 42.53°N, 57.20°W, aircraft course 065° true, altitude 9.4 km.

First sighting: 085° true, 40° above horizon.

Last sighting: 045° true, 5°–10° above horizon.

Duration: 3 s.

Apparent brightness: like full moon.

Color: blue-green, then yellow-red.

Size: 1/4 of full moon.

Information contact: same as above.

Austria, August 11, 2158 GMT.

Observer: K. Frenger.

Location: Gloggnitz, Austria (47.68°N, 15.97°E).

First sighting: right Ascension 21 h 20 min declination +67°.

Last sighting: right Ascension 18 h 45 min declination +40°.

Duration: 12 s.

The fireball was first observed in the constellation Capheus and disappeared in Lyra. It had an initial magnitude of -2, intensifying to -8 on explosion of the bolide. At this point, the shadows of nearby trees could be clearly seen. No noise was heard. An afterglow was visible for 10 s.

Information contact: same as for Atlantic Ocean.

Czechoslovakia-Poland border, October 3, 2300–2400 GMT. The following is a report from Zdeněk Čepelch.

A fireball of -10 maximum absolute magnitude was photographed by at least 2 stations of the European network. The fireball traveled a 52 km luminous trajectory in 2.8 s. No visual observations are available and the time of fireball passage is rather uncertain. The following results are based on 2 photographs of the Czech part of this network.

	Beginning	Maximum Light	Terminal
Velocity (km/s)	18.8	17.8	18.7
Height (km)	73	48	43
Latitude	48.38°N	48.81°N	48.64°N
Longitude	18.73°E	19.11°E	18.18°E
Magnitude	-4	-10	-4
Mass (kg)	9.8	1.3	0
Z R	58.0°	58.0°	58.0°

Fireball type: II.
Meteorite fall very improbable.

	Observed	Geocentric	Heliocentric
Radiant (1950.0)	345°	341°	—
Alpha	4°	—	—
Delta	—	—	301°
Lambda	—	—	2°
Beta	—	—	39
Initial velocity (km/s)	18.8	16.2	—
Orbit (1950.0)			
A	4.0	A.U.	—
E	0.8	—	—
Q	0.88	A.U.	—
Aphelion	7.0	A.U.	—
Omega	227.0°	—	—
Ascending node	180.45°	—	—
Inclination	2.0°	—	—

Meteor shower; perhaps a bright member of Capricornids.
Information contact: same as Czechoslovakia-Austria.

Czechoslovakia-Austria border, November 18, 011332 GMT. The following is a report from Zdeněk Čepelch.

A fireball of -12 maximum absolute magnitude was photographed by 6 Czech stations of the European network. The fireball traveled a 53 km luminous trajectory in 0.7 seconds. A prism spectrum with dispersion of 20 nanometers (nm) in the blue region was photographed from the Ondřejov Observatory. The strongest lines belong to ionized calcium (393–397 nm), ionized magnesium (448 nm) and ionized silicon (635–837 nm) and to neutral sodium (589–590 nm). Most of the medium and faint lines belong to neutral iron, magnesium, and calcium. The following results are based on all available photographs and should be close to final values.

	Beginning	Maximum Light	Terminal
Velocity (km/s)	71.8	70.8	69.0
Height (km)	117.3	61.3	67.5
Latitude	48.821°N	48.850°N	48.855°N
Longitude	15.838°E	15.828°E	15.248°E
Magnitude	-3.8	-12.0	-4.2
Mass (kg)	0.19	0.02	none
Z R	56.8°	—	58.2°

Fireball type: III A I.

Typical cometary fireball belonging to the Leonid Meteor Shower (Parent Comet: Tempel-Tuttle). Meteorite fall impossible.

The increase in brightness during the first half-second corresponds to 17 stellar magnitudes per second (6 million times per second in light intensity), which is the biggest increase of brightness ever observed for a fireball photographed within the European network. The sudden decrease of brightness after the maximum light corresponds to 100 stellar magnitudes per second.

	Observed	Geocentric	Heliocentric
Radiant (1950.0)	153.7°	153.8°	—
Alpha	22.04°	21.82°	—
Delta	—	—	149.1°
Lambda	—	—	17.7°
Beta	—	—	41.5
Initial velocity (km/s)	71.8	70.8	—

Orbit (1950.0)

A	13 (±3)	A.U.
E	0.92	—
Q	0.9845	A.U.
Aphelion	25 (±4)	A.U.
Omega	172.7°	—
Ascending node	235.4483°	—
Inclination	182.2°	—

Information contact: Zdeněk Čepelch, Ondřejov Observatory, 251 65 Ondřejov, Czechoslovakia.

South Europe, November 11, 1736 GMT. Many persons in Austria and Italy observed a brilliant fireball that traveled from northeast to southwest, disappearing below the southwest horizon. Table 4 summarizes a few of the observations. None of the observers reported any sounds.

TABLE 4. Observations for South Europe, November 11

Observer	Location	First Sighting	Last Sighting	Duration	Magnitude	Color	Size	Train
—	80 km northwest of Klegent, Austria (47.2°N, 13.6°E)	190° magnetic, 40° above the horizon	210° magnetic	30 s	like a pyrotechnical flare	white, becoming red	1/2 of moon	persisted 4 min
—	Verona, Italy (45.4°N, 12.3°E)	NE sky	SW horizon	—	—	white-blue	—	none
Teal Lucena	south Marcella, Italy (44.05°N, 10.78°E)	NE sky	SW horizon	—	-11 to -12	white-blue with green-red halo	—	persisted
P. Feppardub	Viterbo, Italy (42.4°N, 12.1°E)	NNE, 50° altitude	SW horizon	10 s	-17	orange	—	wevy train persisted 2–3 s
—	Rome, Italy (41.9°N, 12.5°E)	—	—	—	-15	red-green with white center	—	20°–30° long

*Capt. Henrich, F/O Pitz, F/E Heptner, F/E Hoehe of Luftwaffe flight LH 805 (Tel Aviv-Frankfurt).

New Publications

Applied Water Resource Systems Planning

D. C. Major and R. L. Lenton, Prentice-Hall, Englewood Cliffs, N.J., viii + 248 pp., 1979, \$19.95.

Reviewed by Richard N. Palmer

Design of Water Resource Systems, authored in 1962 by Mass, Hufschmidt, Dorfman, Thomas, Marglin, and Fair (Harvard University Press, Cambridge, Massachusetts) helped to introduce a new perspective in water resource planning. This seminal text, a product of the Harvard Water Program, combined economics and systems analysis with more conventional engineering procedures to produce new methodologies for the evaluation and design of water resource projects. Until this time few practitioners or academicians, allowing for several notable exceptions such as Arthur Morgan and Abel Wolman, had taken as careful and comprehensive a view of the process of water resource development and management. Over the years this text has had a significant influence on other water resource planners and the manner in which they approach problem solving.

In a new text entitled *Applied Water Resource Systems Planning*, this influence is clearly illustrated. Together with 14 coauthors, editors David Major and Roberto Lenton present a successful application of the theory and the techniques suggested by Mass et al. in a study of river basin development in the Rio Colorado in Argentina. The study described in the book was conducted in the mid-1970s at the request of the Argentine government by a team of researchers from MIT and government officials from Argentina. The research performed three primary purposes: to adopt water resource planning techniques to Argentina, to train Argentine professionals in their use, and to apply the techniques to the Rio Colorado. The book focuses on the third of these purposes.

The twelve chapters are divided into three parts. Part 1 gives an excellent background to the problem setting, a description of the methodology used, and an overview of the remaining portions of the book. Part 2 describes four mathematical models developed to analyze the problem. Part 3 presents a parameter input for the model, the results, the interpretations, and the perspectives. Following several of the chapters are appendices that describe in further detail topics presented in the chapters.

The problem addressed in this book was how best to plan for the future development and sequencing of a number of potential hydropower facilities, irrigation systems, and reservoir projects in the Rio Colorado and surrounding basins. The researchers approached their problem with two tools advocated by Mass et al.: mathematical programming and multiobjective economic evaluation. The methodology they developed to solve the problem was a series of mathematical models, differing in purpose and in complexity, that were used sequentially to

sequencing model that optimized investment over a 40-year time horizon. Because of the massive scale of the system, some important components were ignored. For instance, each reservoir was considered as an independent entity, and no attempt was made to derive an optimal operating policy for the system as a whole.

The book is clearly organized and well written throughout. Despite the numerous authors, the writing is surprisingly uniform in style and is highly readable. Terminology and notation, except where isolated, seem to be totally consistent. In short, there is no over the feeling of a disjointed effort which is common among most books with multiple authors. Good references at the end of each chapter allow the reader to pursue topics of interest. The descriptions of the mathematical models developed in this study are exceptionally clear and concise. Of special value are the discussions that relate the various models and illustrate how the models are used to complement one another.

In addition to its numerous positive attributes, however, the book does contain flaws. These flaws are the most striking when the book is viewed as a potential text, as is suggested in the introduction. The introductory chapters that discuss multibobjective planning and mathematical modeling (chapters 2 and 3) are superficial and do not lay the necessary foundation for the techniques that are used in the following chapters. Interested readers must seek the material that is referenced to obtain a complete appreciation of these topics. Insufficient emphasis is placed on the process of model development and on model interpretation. The restricted number of approaches and techniques that are presented in the book prevents it from being a well rounded introductory textbook in water resource systems. At the other extreme, if the models presented in the book can no longer be considered state of the art and are not given in sufficient detail to allow the book to be used as a basic reference or as an advanced graduate text.

Despite the above criticisms, Major and Linton's book would make an excellent supplement to an introductory course in water resources planning. Viewed as a case study, the book illustrates the valuable process of transforming a complex water resource problem into a system of objectives and constraints that can be quantitatively analyzed and, eventually, improve the planning process.

Richard Palmer is with the Department of Civil Engineering, Water and Air Resources Division, University of Washington, Seattle, Washington.

Marine Turbulence

J. C. J. Nihoul, Elsevier, New York, xii + 378 pp., 1980, \$58.50.

Reviewed by John Woods

There has long been a conspiracy among fluid dynamicists of an engineering inclination to reserve the word 'turbulence' for a very special type of nonlinear fluctuations in which three-dimensional vortex stretching drives a cascade of kinetic energy from large scale to small, often with virtually no flux divergence over some portion of the spectrum. The study of such three-dimensionally isotropic (3DI) turbulence has made a major contribution in engineering, but after 75 years of research it is clear that life is more complicated in the ocean, where mixing is normally dominated by nonlinear fluctuations that are not characterized by three-dimensional vortex stretching and are at best only two-dimensionally isotropic (2DI). Rejecting the use of the term turbulence for such important oceanic motion, one of the leading conspirators insists on using the word, in rather rude, term 'turbulence'. This arrogant nonsense has prevailed because the engineers have until recently cornered the market in textbooks and monographs on turbulence.

At last the situation is changing. The development of new tools to measure the fluctuations in the motion and scalar concentrations in the ocean has stimulated theoretical and laboratory studies designed to improve our understanding of

the phenomenon of ocean turbulence in its own right, rather than as a minor application of engineering turbulence. Monographs are beginning to emerge.

The volume under review represents a collection of 21 papers presented at the 11th International Colloquium on ocean hydrodynamics (Lège, May 1979). The Colloquium was held in association with the second IOE-APSO Symposium on 'Turbulence in the Ocean'. Another book, containing commissioned review papers presented at the symposium will be published soon. The two volumes neatly complement each other: The present volume contains papers reporting results of research projects, while the latter will contain broader reviews. Both contain material covering the whole spectral range encountered in the ocean, from millimeters to megameters. Nihoul, in an introductory chapter to 'Marine Turbulence', identifies the features that distinguish what we find in the ocean from what the engineer finds in his/her world. The key factor is that, in the interior of the ocean (i.e., away from the boundary layers), almost all the turbulent kinetic energy occurs as motions with large Richardson number and small Rossby number. Classical 3DI turbulence occurs only at scales (~ 1 m) much smaller than that of structure in the mean circulation, so there is a spectral gap several decades wide between the input of turbulent kinetic energy and its entry into the 3DI turbulence that can whisk it speedily to molecular dissipation. Very little energy succeeds in leaping this gap, with the result that 3DI turbulence occurs only sporadically in short-lived bursts in otherwise laminar flow. The central problem of turbulence in the interior of the ocean is to understand the processes occurring at high Richardson number/Rossby number.

How do the eddies, fronts, and fine structure relate to each other and to the Rossby and internal buoyancy waves propagating through them? Pechavsky summarizes the contribution of classical 2DI turbulence theory to this problem, following the approach of his well-known monograph. One of the themes to emerge from discussions at the Lège meeting was the need to take an integrated view in which all these motions, waves included, contribute to the overall budgets of the variances of momentum, vorticity, temperature, salinity, etc. It is therefore entirely consistent to find papers by Colin de Verdière on Rossby waves and Oranski and Ceraoli on internal waves. There is no contribution in this volume on the eddies (perhaps because they will be treated extensively in a monograph now being edited by Allen Robinson), but Fedorov reports on a case study designed to illuminate the complicated phenomenon of front-line structure interaction. That takes us up to page 100.

The remaining 278 pages are devoted to papers on the occurrence of 3DI turbulence in the ocean, mainly in the boundary layers. This is probably a fair balance in terms of effort in the research community, but not, I would have thought, if judged in terms of either the proportion of the spectrum covered by 3DI turbulence (about 0.001%) or in terms of practical applications, almost all of which lie at large scales.

But, brushing aside these reservations, let us see what topics are included. The first theme is the cascade of kinetic energy to molecular dissipation, with contributions from Dillon and Caldwell (abstract only), Oakley and Elliott (documenting the correlation between the wind speed and dissipation in the wind mixed layer), Osborn (measurements below the wind mixed layer), and Ozmidov (ditto). There is still some uncertainty about the interpretation of the microscale measurements on which dissipation estimates are based; there are inconsistencies with measurements of scalar variance spectra (represented here by Gregg and Gibson). The next theme is the generation of 3DI turbulence in the interior of the ocean by shear instability (field evidence from Belyaev) and double diffusive instability (fascinating theoretical expositions by Lumley, and by Placzek and Toomre, in which we see a geophysically important phenomenon simulated on a computer by a numerical model that has no need to parameterize unresolved fluid motion). Naturally, many contributors are concerned with the turbulence in boundary layers. Revault d'Allonnes and Caulliez present a progress

Marine Ecology

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report on measurements from the Bouée Laboratoire, which can be compared with Dillon and Caldwell data already mentioned. Five papers deal with the bottom boundary layer in the presence of strong tidal currents. Bowden and Ferguson measured the vertical profile of shear stress by the eddy correlation method; and for the same area, Wolf estimated very similar shear stress values from external data and Swift used an analytical model with tidally varying turbulent kinetic energy to calculate residual currents. Then come two papers on the shear effect on dispersion in tidal flow, by Nihoul, Runfola and Roisin and by Werulicz and Benque. The final contribution, by Veth, describes a new tool—the laser-Doppler velocimeter—that may make a significant contribution to ocean turbulence observations in the future.

Conference proceedings tend to be rather patchy, and this is no exception, but *Marine Turbulence* contains much useful material and is recommended not only to those in the business, but also to the general oceanographer and, yes, to those who still believe in the restricted engineering definition of turbulence.

John Woods is director of the Regional Oceanography department, Institut für Meereskunde Kiel, Düsternbrook Weg, Germany.

Marine Geodesy, vol. 3, nos. 1-4

N. K. Saxena (Ed.), Special Issue on Interaction of Marine Geodesy and Ocean Dynamics, Crane, Russak, New York, 436 pp., 1980, \$48.00.

Reviewed by David Wells

A symposium on the 'Interaction of Marine Geodesy and Ocean Dynamics' was held in Miami, Florida, October 10-13, 1978. The symposium was sponsored by AGU and six other organizations and consisted of four technical sessions, four concurrent workshops, and a final plenary workshop. These proceedings contain a summary of the workshops and 15 out of the 28 papers presented during the technical sessions.

The interactions between marine geodesy and ocean dynamics considered in these proceedings separate into the horizontal (a one-way interaction, the provision of precise positioning by marine geodesists to ocean dynamists), and the vertical (two-way interactions in several common-interest aspects of sea surface height). The interactions are most intimate in the analysis of satellite-borne radar altimetry, which senses the instantaneous sea level, as affected by both the marine geodesists' 'signal' (the marine geoid) and by the ocean dynamists' signals (variously due to tides, currents, storm surges, wind, and atmospheric disturbances). This intimate interaction, in which for each the signal of the other is often noise, is well represented in the content of these proceedings.

The horizontal interaction is considered in two papers. Haislip reported on the status of radio navigation systems maintained by the U.S. Coast Guard. Seaber presented results from two Transit Satellite Doppler studies, on the effect of drilling rig metal decks on height determination, and on the feasibility of precisely tracking moored buoy movements. The vertical interaction is represented by three groups of papers concerned with ocean circulation, global ocean tides, and the marine geoid.

Gatto used remote sensing techniques to determine circulation patterns. Papers by Chew and by Molnar discuss currents in the Florida Straits and in the Caribbean Sea and in the Gulf of Mexico, respectively, each touching (inconclusively) on the controversial interaction between static and geoidal leveling. Global ocean tide (GOT) models are of practical interest in the analysis, for example, of satellite altimetry data, satellite orbit perturbations, and seabed gravimetry. Zaiter traced the complementary developments of GOT models and of geoidal (ocean bottom) tide gauges, data from which are invaluable for testing and tuning GOT models. Three approaches to GOT models were described by Schwiderski (in two papers), Parkes, and Estes. In the first two cases, a theoretical model was used to interpolate between tidal data from coastal and inland stations. The M_2 constituent obtained by Schwiderski agreed with the M_2 constituent from independent geoidal data to within 2 cm in amplitude and 6° in phase. Parkes presented maps of some geophysically useful parameters de-

rived from modeled M_2 , S_2 , and K_1 constituents. Estes presented a purely theoretical GOT model (independent of tidal or geoidal data) and used it in a simulation of the effect of unmodeled systematic orbit errors on the problem of extracting ocean tide information from satellite altimetry.

Determination of the marine geoid from satellite altimetry is discussed in four papers. Marsh showed that in the short term (treating sea surface heights owing to dynamic effects as noise) altimetry is useful in reducing geoid uncertainties. Brace compared altimetric geoid heights with heights from several geopotential coefficient sets and altimetrically derived mean gravity anomalies with those from marine gravimetry. Torge presented a gravimetric geoid for the North Sea and compared it to one derived from altimetry. For the longer term, an integrated approach to extracting both geoid and dynamic signals from altimetry is needed. Parra used results from the western North Atlantic to show that gravimetric

geoids can be corrected in local areas free of permanent geostrophic features and that the study of temporal variations in quasi-steady dynamic features is the most useful contribution of altimetry to ocean dynamics.

GEOS-3 altimetry was used for all the altimetric studies reported here. McArthur described the more advanced SEASAT-1 altimeter, together with proposed future improvements. Ironically, the failure of SEASAT-1 was announced during this symposium.

An introductory paper by the conference co-chairmen and session chairmen summarizes the workshops, which dealt almost exclusively with the altimetric connection between marine geodesy and ocean dynamics. This is an excellent tutorial paper on the present and potential uses of this new tool, full of ferment and excitement and occasionally contradictory. (One workshop concluded that mesoscale eddies can be studied with existing altimetry; another workshop con-

cluded that altimeter performance must first be improved considerably.)

Appearing in a refereed journal, these proceedings are certainly more accessible, and perhaps more carefully considered in content, than if they had been produced in a less formal way. The full flavor of the symposium is elusive, however, since nearly half of the papers presented are neither printed nor even listed by title in these proceedings. In particular, more could have been included on sea level variations from ocean dynamics effects other than tides. Nevertheless, the papers here represent a valuable and much needed contribution to our understanding of the interactions between marine geodesy and ocean dynamics and to the dialogue between marine geodesists and ocean dynamicists.

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Applications are due February 15, 1981. Salary is competitive with industrial standards. Inquiries and applications should be sent to John Wickham, Director, School of Geology and Geophysics, University of Oklahoma, Norman, OK 73019.

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Synoptic/Dynamic Meteorology. Description: The Geophysical Institute and Division of Geosciences, University of Alaska, seeks applications from qualified scientists for a full-time (12-month) faculty position at the Assistant or Associate Professor level. The successful candidate will be expected to prepare and submit research proposals to external agencies and to work cooperatively with ongoing research programs. He/she will be also expected to teach occasional courses in synoptic/dynamic meteorology at the upper division and graduate levels.

Qualifications: Ph.D. in meteorology. Research experience in advanced analysis and diagnostic studies of global-scale meteorological processes is essential, preferably over the full height of the atmosphere (0-100 km). Preference will be given to applicants who can utilize their expertise in synoptic/dynamic meteorology to synthesize the results of various ongoing research projects in mesoscale and large-scale meteorology, cloud physics, radiation, oceanography, and space physics into a better understanding of the large-scale meteorology of the North Pacific and polar regions. Teaching experience at the undergraduate and graduate levels is desirable.

Salary: Upward to \$34,800 (Asst. Prof.) or \$43,300 (Assoc. Prof.) per year, dependent upon qualifications and experience.

Applications: For further information, including recent annual research report, write to Director, Geophysical Institute, University of Alaska, Fairbanks, AK 99701. Closing date for applications is February 26, 1981.

The University of Alaska is an equal opportunity/affirmative action employer.

Sedimentary Petrologist. The Geology Department at the University of Vermont is seeking a sedimentary petrologist for a tenure track position at the assistant professor level. Research and teaching specializations should be in classic sedimentary petrology with potential ancillary interests in petroleum geology, geomorphology, and hydrology. It is expected that the successful candidate will establish a field-oriented research program which includes supervision of graduate (M.S.) and undergraduate students. A Ph.D. is required and teaching experience is highly desirable. The Geology Department of the University of Vermont is a seven-member department having an M.S. program and a definite commitment to excellence in undergraduate education. Applications will be accepted until April 1, 1981.

Candidates should send a resume and arrange for three letters of reference to be sent to John C. Oriskany, Acting Chairman, Department of Geology, University of Vermont, Burlington, Vermont 05405. The University of Vermont is an equal opportunity/affirmative action employer.

Faculty Position. The Department of Geology of the University of New Mexico seeks applicants for a position in clay mineralogy, low-temperature geochemistry, carbonate petrology, or economic geology. The appointment may be at the assistant, associate or full professor level contingent on approval of funding from the university. The individual must be strongly committed to teaching at both the undergraduate and graduate levels. In addition, he or she will be expected to develop a vigorous research program in his or her field of specialty and will be expected to supervise graduate students at the M.S. and Ph.D. levels. The closing date for application is April 15, 1981. Applicants should send a resume, undergraduate and graduate transcripts, three letters of reference, and a brief discussion of research interests to Rodney C. Ewing, Chairman, Department of Geology, University of New Mexico, 87131. The University of New Mexico is an equal opportunity/affirmative action employer.

Geophysical Research Associate. Western Observatory at Boston College seeks M.S. in geophysics (doctorate work desirable), familiarity with line and frequency domain analysis techniques, and knowledge of FORTRAN programming. Opportunity for independent research along with assigned responsibilities relating to New England seismic network. Salary to \$20,000 depending on qualifications and excellent benefits. Send letter and resume to Donna Rogers, Associate Director of Personnel, Boston College, 140 Commonwealth Avenue, Chestnut Hill, MA 02157. An equal opportunity/affirmative action employer.

Drexel University/Atmospheric Scientist. Three tenure track faculty positions are being advertised starting July 1981. Applicants are solicited for positions in the Department of Atmospheric Science, Ph.D. with independent research experience in one of the following areas of atmospheric science: general circulation, climate dynamics with application in satellite meteorology; atmospheric optics, experimental or theoretical with emphasis in aerosol scattering; boundary layer turbulence modeling and atmospheric chemistry modeling. Rank and salary commensurate with experience. Send resume and references to Dr. William W. Ertel, Head, Department of Physics and Atmospheric Science, Drexel University, Philadelphia, PA 19104. An equal opportunity/affirmative action employer.

Program Manager/Meteorology. Oceanographic Services, Inc., is seeking qualified applicants for the position of program manager for meteorological studies. Applicants should have an M.S. or Ph.D. in meteorology or atmospheric sciences, plus experience in the field. A broad general knowledge of air pollution, and an understanding of the air pollution regulatory environment is helpful. Interested persons should send resume, references, and salary history to R. C. Banks, Oceanographic Services, Inc., 25 Castilian Drive, Galesia, CA 93317.

Research Plasma Physicist. Berkeley Scholars, Inc. has openings in D.C. areas. Must be eligible for Ph.D. in plasma physics with specialization in and abstracts presented at theory and numerical simulation of magnetic shear effects on instability phenomena as applied to ionospheric and magnetospheric problems. 1 yr. work experience in the field is required. Salary is \$20,000 per yr., 40 hrs. per wk. Send resume directly to Berkeley Scholars, Inc., P.O. Box 963, Berkeley, CA 94701. An AVEOE.

RESEARCH OCEANOGRAPHER

The Radar and Optics Division of ERM requires a Radar Oceanographer, preferably at the PhD level, to function as head of the Oceanographic Measurements and Analysis Group of the EM Measurements Department. Experience as an Oceanographer including EM measurements of oceanographic phenomena is required. Experience in the management of research programs is desirable. Candidates should have knowledge of EM remote sensor systems and techniques. The EM Measurements Department conducts research programs to apply EM measurements techniques to oceanographic problems.

ERIM, a non-profit corporation, is a center of research and development on sophisticated sensors and data processing techniques used by the Department of Defense and other agencies engaged in remote sensing.

ERIM is located adjacent to the campus of The University of Michigan in Ann Arbor. The Ann Arbor area has exceptional academic, cultural, entertainment and recreational opportunities.

Send your resume and salary requirements in confidence to John J. Melik, U.S. citizenship is required.

ERIM

P.O. Box 8618

Ann Arbor, Michigan 48107

An equal opportunity employer.

Queens College. Position for 1-2 years as a full-time replacement starts September 1981. Specialties requested: geochemistry (organic, environmental, or exploration); exploration geophysics; groundwater geology. A Ph.D. required. Applications should include a resume and three references. Send to: O. H. Spedding, Department of Earth and Environmental Sciences, Flushing, NY 11367. Queens College is an affirmative action/equal opportunity employer.

Geophysicist/University of South Carolina. The University of South Carolina anticipates a new faculty appointment in geophysics for 1981, subject to adequate legislative funding. We are especially interested in individuals who have expertise in the fields of exploration geophysics, seismic interpretation, or solid earth geophysics. This would be a 6-month, tenure track position at the assistant or associate professor level, beginning August 1981. Some start-up funds are available for major equipment purchases. The individual who fills this position would join the growing geophysical component of the Geology Department, which currently emphasizes sedimentology, regional tectonics, and paleomagnetism, and would develop an aggressive research program in his or her specialty.

Please send vitae and names and phone numbers of three individuals we may contact for reference to: Willard S. Moore, Chairman, Search Committee for

Geophysicists, University of South Carolina, Columbia, SC 29208. Closing date for this announcement is March 15, 1981.

The University of South Carolina is an affirmative action/equal opportunity employer.

Scientist/Meteorological Engineers. Science Systems and Applications, Inc. (SSAI) has positions for programmers, analysts, scientists and engineers to engage in scientific modeling and data analysis activities in the areas of: 1. Plasma/ionospheric physics theoretical simulations; 2. Radio wave propagation/scattering studies; 3. Satellite data analysis; 4. Weather/climate and severe storms studies; 5. Atmospheric/hydrodynamic; 6. Solar and planetary physics and astronomy; 7. Computer image processing and systems displays; 8. System software/hardware engineering; 9. Nuclear fusion/ionization; 10. Applied mathematics. These positions involve working with NASA/NOAA/Navy satellite in meteorology, Washington, D.C. area. A strong background in numerical simulations, and experience in working with large scale computers is required for entry level to senior scientist/engineer positions. SSAI provides a congenial academic environment, pays liberal fringe benefits and awards bonuses to its employees. Please send your resume with salary history and references to Science Systems and Applications Inc., The Aerospace Building, Suite 140, 10210 Greenbelt Road, Seabrook, MD 20801.

Meetings

Recent Earthquakes Symposium

A call for papers for the symposium "Reports of Recent Earthquakes" has been made by Ziro Suzuki, second vice president of IASPEI. The symposium will be held July 22, as a part of IASPEI's 21st General Assembly, at the University of Western Ontario in London, Ontario.

Abstract forms are available from Suzuki at the Geophysical Institute, Tohoku University, Sendai 980, Japan. Requests for the forms should include author name and address, tentative paper title, and name, piece, and time of the earthquake to be reported. Completed abstract forms should be mailed by March 1 to A. E. Beck, Department of Geophysics, University of Western Ontario, London, Ontario N6A 5B7, Canada. A copy should be sent to Suzuki. Some deadline flexibility will be allowed, but authors should receive permission from the committee. Papers on earthquakes that occurred during the second half of 1980 can be accepted after March 1.

Time restriction: the number of papers on each earthquake to two. Review papers rather than personal studies are preferred.

European Geophysical Meeting

A call for papers has been issued for the Eighth Annual European Geophysical Society Meeting, scheduled for August 24-29 in Uppsala, Sweden. Abstracts—one original and two copies—should be sent to K. M. Storevick, Chairman Program Committee, Institute of Geophysics, University of Bergen, Allég. 70, N-5014 Bergen University, Norway. Deadline for receipt of abstracts is June 1.

In addition to 13 symposia, one workshop, and an excursion to a meteorite-impact structure, there will be two society lectures. H. Alfvén of Stockholm will appear on plasmas in the cosmos and the laboratory, and H. Moritz of Graz will give a lecture entitled "The Figure of the Earth."

Applications for travel awards for young scientists are due March 31. Forms can be obtained from the EGS General Secretary, 6 Carlton House Terrace, London SW1Y 5AG.

More information about the meeting, which will run simultaneously with the Uppsala Calceolone Symposium, can be provided by the Local Organizing Committee, C. E. Lund, Chairman, Box 558, S-75122, Uppsala, Sweden.

Hydrometeorology Session

The 15th Annual Congress and Annual Meeting of the Canadian Meteorological and Oceanographic Society (CMOS) will be held at the University of Saskatchewan, Saskatoon, Saskatchewan, on May 27-29. The focus of the Congress will be hydrometeorology; scheduled are sessions on waves and tides, drought management, the Canadian Climate Program, environmental assessment, stratospheric dynamics, remote sensing, and polluted precipitation. In addition, sessions on air-pollution meteorology, sponsored by a CMOS special interest group, will be conducted concurrently.

Authors wishing to present papers at the congress or at the special air-pollution sessions should submit abstracts of fewer than 300 words by February 1. Address all correspondence to Barry Goodison, Hydrometeorology Division, Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ontario M3H 5T4 (call 416-867-4914). Authors should indicate in which session they wish to be included.

California Mining Association

California's mineral industry and its impact on the nation will be the focus of the 1981 California Mining Association Annual Meeting in San Diego, March 5-7.

Technical aspects of California mining and political problems which concern the industry will be emphasized. More than 200 representatives from major industrial mining firms in the state are expected to attend.

Registration is \$75 per person; spouse registration is free. For additional information contact the association at P.O. Box 3, Jackson, California 95642, or call (209) 223-1129.

Geodetic Networks and Computations

An international symposium on geodetic networks and computations will be held in Munich, August 31 to September 5. The symposium, sponsored by the International Association of Geodesy, will take place at the Bavarian Academy of Sciences.

Topics to be covered at the symposium include objectives of geodetic networks, status reports, and future plans; optimal design of geodetic networks; network analysis models; space techniques for terrestrial networks; combination of horizontal, vertical, and gravity networks; and computational problems in classical and nonclassical adjustment models. For additional information and registration forms, write to Deutsche Geodätische Kommission, Bayerische Akademie der Wissenschaften, Martenplatz 8, D-8000 München 22.

Snow Chemistry: Call for Papers

A call for papers has been issued for the 38th Eastern Snow Conference, scheduled for June 4-5 in Syracuse, New York. A special session will be held on snowpack and snowfall chemistry.

Authors wishing to present a paper should submit an abstract before February 15 to Barry E. Goodison, Program Chairman, Hydrometeorology Division, Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ontario M3H 5T4, Canada (call 416-867-4914).

IASPEI Workshop: Seismic Modeling of Laterally Varying Structures

During the past 10 years, significant progress has been made in the methods of collection and analysis of seismic reflection and refraction data. This progress has led to the development of new models for the structure and composition of the earth's crust, based on sophisticated analysis of numerous profiles in many areas of geologic importance. The third triennial meeting of the IASPEI (International Association of Seismology and Physics of the Earth's Interior) Commission of Controlled Source Seismology was convened in Park City, Utah, on August 11-17, 1980, to bring together seismologists and geologists to explore and assess the progress of controlled source techniques (controlled sources include explosions, air guns, and Vibroseis-type sources), and to evaluate the significance in terms of current models of the seismic velocity structure and composition of the crust and upper mantle. Particular attention was paid to the progress and problems in the modeling of two- and three-dimensional structures.

The Park City location of the conference was ideal for the contemplation of the complex structures that we are presently attempting to model. The effects on the crust of the action of tectonic forces were easily discernible from the air during the approach to the Salt Lake City airport, and on the ground during the field trip into the Wasatch Mountains led by R. B. Smith of the University of Utah.

Two and one half days of the 5-day conference were used to discuss different interpretations of the seismic refraction data collected in Saudi Arabia by the U.S. Geological Survey in 1978 (Blank et al., 1979; Lamson and Leone, 1979). The format of this portion of the meeting was unlike most other scientific workshops. The complete refraction data set had been distributed to the participants well in advance of the meeting, giving each seismologist (or team of seismologists) time to thoughtfully analyze the same data. The use of a common data base allowed for a kind of in-depth examination of issues of interpretation that is not possible in traditional workshops which are based on diverse data sets.

A discussion of the geologic framework of Saudi Arabia and the southeastern Red Sea was particularly pertinent because all proper seismic interpretations are constrained by the known surface geology. (The geologic map of Saudi Arabia was distributed to all participants along with the seismic data set.) The discussions began with an introduction to the geologic problems of Saudi Arabia by H. R. Blank and an outline of the planning and goals of the 900-km-long refraction profile (see the figure, part A) by M. Q. Assad. This was followed by a series of speakers who explained their team's interpretation of the data and the methods that they used to derive velocity-depth structures. In the course of these presentations it became evident that the main source of differences in the final models is the phase correlation of the data. This term "phase correlation" refers to the process of identifying, within a seismic record section, those arrivals which reflect or reflect from the same feature (or portion) of the crust or mantle velocity structure. For example, the phase P^* refracts in the middle crust, while PmP reflects from the M discontinuity. A knowledge of the expected amplitude and frequency of a particular phase, based on experience and theoretical considerations, facilitates its correlation in the record section, but the complexity of the typically observed wave field leads to a degree of subjectivity in the interpretation of the phases. Given identical phase correlations, different methods of travel time and amplitude analysis of these phases will produce nearly the same result. Conversely, different correlations will result in markedly divergent models. These points can be appreciated from the comparison of the models of the Arabian shield (see figure, part

B) to those of the Red Sea-continent transition (see figure, part C). For the most part, the teams of interpreters agreed on the phase correlation of the profiles between shot points 1 and 5 (see figure), and the resultant models reflect the agreement. However, the correlations and interpretations of the data crossing the Red Sea-continent transition were diverse, which ultimately led to quite different models for that region (see figure, part C).

A few highlights of the meeting on the interpretation of the Saudi Arabian refraction data are summarized below. These few impressions do not completely characterize the great amount of interpretive skill brought to bear on the data and the lively and constructive discussion that ensued.

(1) The upper crust (21 km thick) of the shield has a near-surface velocity of 6.1 km/s and, in most regions, a positive velocity gradient of 0.01-0.02 km/s/km. Low velocity zones may be present in some regions.

(2) The lower crust (19 km thick) of the shield is separated from the upper crust by a seismic discontinuity or smooth transition of 0.2-0.4 km/s. The average velocity of the lower crust is about 6.7 km/s.

(3) The M discontinuity is probably a transition zone 2-5 km thick and occurs at a nearly constant depth of about 40 km. Uppermost mantle velocity is 8.0-8.1 km/s, and there is evidence for fine structure within the lithosphere.

(4) The structure of the Red Sea-continent transition remains uncertain with the currently available data. The range of proposed models is indicated in the figure, part C. Improved models would result from the recommendations below.

A general consensus was reached on recommendations for future seismic refraction and reflection work in areas with strong lateral velocity heterogeneous structure, such as the Red Sea-continent transition in western Saudi Arabia:

(1) Parallel to-structure refraction profiles are needed in regions of complex structure. In the present case, refraction profiles are needed along the coastal plain and in the Red Sea.

(2) Perpendicular to-structure profiles must be densely recorded and should include considerable data redundancy.

(3) Critically placed seismic reflection profiles would help resolve details in the areas of greatest structural complexity. In the present case, reflection profiles crossing the Hijaz Azir Escarpment (see figure, part A) would help in understanding the structure across this rift boundary.

The commission officers were (chairman) S. Mueller, ETH-Zurich, Switzerland, and (secretary) J. Ansgore, ETH-Zurich, Switzerland. The local organizers were D. P. Hill, Menlo Park, California; J. A. Orcutt, La Jolla, California; and R. B. Smith, Salt Lake City, Utah.

Acknowledgments

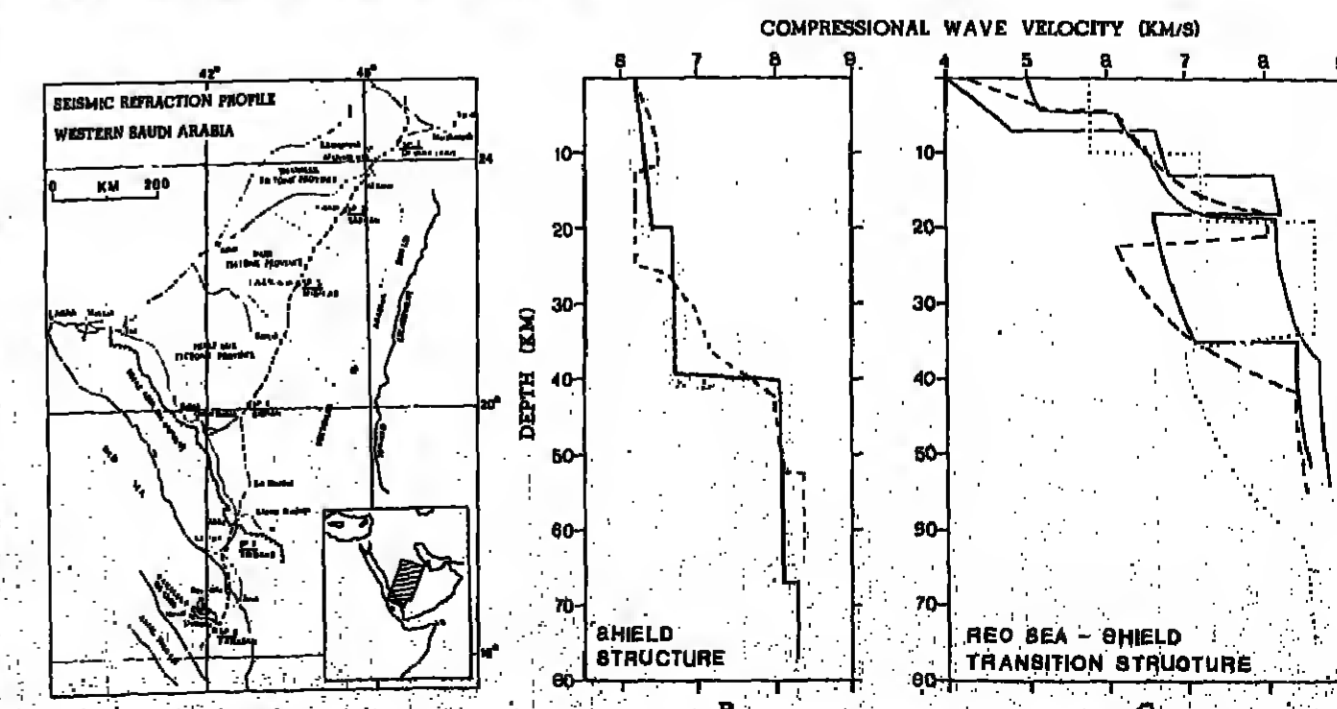
Financial support for the workshop was provided by the Office of Naval Research and the U.S. Geological Survey. We thank the Directorate General of Mineral Resources, Saudi Arabia, for permission to use the seismic refraction data for this workshop.

References

Blank, H. R., J. H. Healy, J. Rollier, R. Lamson, F. Fisher, R. McClean, and S. Allen, Seismic refraction profile, Kingdom of Saudi Arabia: Field operations, instrumentation, and initial results. *Rep. 259*, 49 pp., Saudi Arabian Mission Proj., U.S. Geol. Surv., Menlo Park, Calif., 1976.

Lamson, R., and L. Leone, Saudi Arabia seismic refraction profile: Data set, Volume 1 and 2, *Geol. Surv. Open File Rep. (U.S.)* 79-1601, 1980.

This meeting report was prepared by Walter D. Mooney, USGS, Menlo Park, California.



(A) Location map: UBSG-conducted seismic refraction investigation of western Saudi Arabia and the southeastern Red Sea: shot points (SP), profile line (dashed line), and tectonic provinces. (B) P-wave velocity structure of the Arabian Shield, prepared by workshop participants: shaded region outlines the range of velocities of most models; solid line is a typical example; while dashed line is an alternative model. (C) Four P-wave velocity structures for the Red Sea-Shield transition: the data were sparse in this laterally inhomogeneous region, making possible these radically different interpretations.

AGU

Stephen J. Burges—New WRR Editor

The "tower of Babel syndrome" is the most important problem facing water-resources researchers, says Stephen J. Burges, the new coeditor for hydrology and physical, chemical, and biological sciences for Water Resources Research (WRR). Burges was appointed to a 4-year term which began November 1. He succeeds R. Allan Freeze.

Specialized research that lacks a sense of connection to other aspects of hydrology characterizes the syndrome, Burges explained. He traces this scattering of interests back to 1966 with the "evolution" of the third-generation computer.

To help add coherence to WRR's coverage of hydrology, Burges plans some changes. With the addition of four associate editors, the breadth of topics will be increased to include ecological modeling, sediments, and precipitation. In addition, Burges will ask authors to explain in a paragraph at the beginning of their papers how the research relates to other water-resources problems. Authors also will be requested to identify the status of research described in the paper, and to state clearly whose work or computer models the research uses.

Burges said that he and coeditor Jared Cohon hope to achieve a better balance of topics and to increase readership with these changes.

Under Burges, the associate editors will continue to play a major role in choosing reviewers and in maintaining the high standards of WRR; the basic management style used by Freeze has been found to be effective. In addition, Burges plans to continue to solicit appropriate review articles to add balance to WRR. Freeze initiated solicitation of these articles; Burges and Cohon plan to coordinate their selection of review topics to bring the two major divisions of WRR closer together.

Following completion of his Ph.D. in civil engineering at Stanford, Burges joined the University of Washington faculty in 1970. His undergraduate degrees (physics, mathematics, and civil engineering) were taken at the University of New-Castle, Australia. His research and teaching have focused on the application of systematic approaches to analysis and design of water-resource systems, with an emphasis on stochastic hydrology.

"At heart I'm a civil engineer," Burges said. "I also like using a systematic approach to problem solving." Surface water-



storage reservoir dominate his interests. He said that he is also intrigued by urban water problems, including large-scale systems and flood/drought research. He views stochastic hydrology as an essential tool for the future. "We need a method to determine reliability of water systems."

Burges said he looks forward to working closely with Cohon and maintaining the high standards set by previous editors. Burges noted that they are indebted to Freeze for his outstanding editorial leadership and want to thank him publicly.

